~~Can~~ Canadian Society of Civil Engineers

HANDBOOK

OF SOME

ENGINEERING WORKS IN CANADA

PREPARED UNDER THE DIRECTION OF THE

CANADIAN SOCIETY OF CIVIL ENGINEERS

FOR THE

MEMBERS OF THE INSTITUTION OF CIVIL ENGINEERS
OF ENGLAND

ON THEIR VISIT TO CANADA,

SEPTEMBER TWENTIETH TO TWENTY-SEVENTH

1904

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HANDBOOK

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ENGINEERING WORKS IN CANADA.

In the preparation of this work the following books, among others, have been consulted:—

The Statistical Year Book of Canada (1904).

The Annual Report of the Department of Railways and Canals (1904).

The Montreal Electrical Handbook.

American Grain Elevators (John S. Metcalfe Co.).

system of the St. Lawrence. [illegible]
nearly two-thirds of the Dominion of Canada with an average elevation of about 1,000 feet above the level of the sea,—pre-eminently a region of water ways, and including the great Laurentian Mountain range. In this area are found the other great river systems, the Nelson and the Mackenzie.

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The Dominion of Canada extends from 42° N. latitude (the latitude of Constantinople) to the Arctic Ocean, and from 60° W. longitude to 140° W. longitude.

It includes the various provinces of Quebec, Ontario, New Brunswick, Nova Scotia, Prince Edward Island, British Columbia, Manitoba, North West Territories, Yukon Territories and Ungava. This territory, nearly as large as Europe and about twenty times as large as Great Britain and Ireland, is estimated to contain a total area of 3,745,574 square miles. From a physical point of view the whole region may be divided into an eastern and western division. The eastern division comprises three areas. 1st. The South Eastern area, bounded by the line of the River and Gulf of St. Lawrence from Belle Isle to Quebec, thence by a line running in a southerly direction to Lake Champlain. This section is generally hilly and sometimes mountainous, with fine stretches of agricultural and pastural lands. 2nd. The Southern and Western areas, presenting in the main a broad, level and slightly undulated expanse of fertile country, with occasional step-like ridges or rocky escarpments. The main hydrographical feature is the chain of lakes with an area of 150,000 square miles, contributing to the great river system of the St. Lawrence. 3rd. The Northern area embracing nearly two-thirds of the Dominion of Canada with an average elevation of about 1,000 feet above the level of the sea,—pre-eminently a region of water ways, and including the great Laurentian Mountain range. In this area are found the other great river systems, the Nelson and the Mackenzie.

The Western division may be divided into two sections. The first stretches from the Red River Valley to the Rocky Mountains. Here, between the latitude of 49° and 50°, is the great prairie rising in the

west in three terrace like elevations, the lowest of which is 700 feet, and the third about 3,000 feet above the level of the sea. North of the 54° parallel the country passes again into forest.

The second division extends from the western portion of the prairie to the Pacific Coast, a distance of 400 miles. It includes the Rocky Mountains and the Gold and Cascade ranges, whose summits are from 4,000 to 16,000 ft. high, the country being on the whole densely wooded.

TABLE I. AREA OF THE PROVINCES IN THE DOMINION OF CANADA.

Provinces and Districts.	Area Square Miles.		
	Water.	Land.	Total.
Original Confederation :			
Ontario	40,354	220,508	260,862
Quebec	10,117	341,756	351,873
Nova Scotia	360	21,068	21,428
New Brunswick	74	27,911	27,985
Provinces Admitted :			
Manitoba	9,405	64,327	73,732
British Columbia	2,439	370,191	372,630
Prince Edward Island	—	2,184	2,184
Districts Created :			
Keewatin	13,419	456,997	470,416
Assiniboia	600	88,279	88,879
Saskatchewan	3,772	103,846	107,618
Alberta	362	101,521	101,883
Athabaska	8,805	243,160	251,965
Yukon	649	196,327	196,976
Mackenzie	29,548	532,634	562,182
Ungava	5,852	349,109	354,961
Franklin	—	500,000	500,000
Totals	125,755	3,619,819	3,745,574

The area of agricultural and timber lands in the Dominion is estimated at 2,000,000 square miles, while the area of land suitable for the cultivation of wheat is about 1,000,000 square miles or 640,-000,000 acres.

In the far northwest where the isothermal lines rise high under the influence of the Japan current, the forest reaches the shores of the Arctic Ocean.

The circuitous coast line of the Atlantic, measures 10,000 miles. The entire country abounds in broad lakes and flowing waters, and the abundance of streams and the regularity of summer rains preclude the possibility of drought.

The Dominion contains the largest portion of fresh water upon the globe—where 2,000 miles from the ocean the traveller may lose sight of land.

POPULATION.

The population of Canada is approximately 5,500,000, of which number about 100,000 are Indians. The following table shows the distribution according to the Census years of 1901 and 1891:—

TABLE II.

Province.	Population.		Persons to the Square Mile. 1901.
	1901.	1891.	
Prince Edward Island	103,259	109,078	51.6
Nova Scotia............	459,574	450,396	22·3
New Brunswick	331,120	321,263	11·8
Ontario..........................	2,182,947	2,114,321	9·9
Quebec	1,648,898	1,488,535	4·8
Manitoba	255,211	152,506	3·9
British Columbia	178,657	98,173	0·4
Provisional Districts..............	211,649	98,967	0·5
Total	5,371,315	4,833,239	

CLIMATE.

It is manifestly impossible to give any general description of the climate of Canada as a whole. The country is so extensive, the area of the fresh water ways so great, that different sections have markedly different qualities of climate.

The chief natural conditions affecting the climate are:—1st. The Japanese current on the west coast which moderates the climate of the neighbouring coasts for many miles inland. 2nd. The polar current from Davis Straits on the east coast, which causes a colder climate than that of England. 3rd. The Rocky

Mountains, which deprive the humid winds from the ocean of their moisture, so that the rainfall of the Central region is comparatively light.

The rainfall in the east is ample for all agricultural purposes.

NOVA SCOTIA.—On the whole the climate of Nova Scotia is remarkably temperate, although there are extremes of heat and cold. The cold weather lasts from the end of December to the first of March. Spring is brief and autumn a most delightful season.

NEW BRUNSWICK.—The climate of New Brunswick is very healthy, though the winters are severe and the summers hot. Winter begins early in December and lasts until the end of March. The snow fall in the north is heavy, while in the south the winters are more open. Autumn is the most pleasant season.

PRINCE EDWARD ISLAND.—The climate of Prince Edward Island is almost perfect. It is singularly free from extremes of heat and cold, and there are, as a rule, no sudden changes.

QUEBEC.—The province of Quebec presents considerable variety of climate, but there are everywhere these prevailing features—cold winters, short springs, and long, bright, sunny summers. Snow usually lasts from the middle of December to the middle of March, and the intense cold is modified by the dry, bracing atmosphere.

ONTARIO.—There is a great diversity of climate in the Province of Ontario. In the north the climate is more moderate than in the south, though even there it is by no means severe.

MANITOBA.—In Manitoba the winters are severe, with no thaws from the first of November to the end of February. The spring is delightful. June and July are rainy months but September and October are bright.

NORTH WEST TERRITORIES.—The climate of the North West Territories is one of the healthiest in the world, with a clear, dry atmosphere, abundance of fresh breezes and bright sunshine. In some parts the winters are severe, and blizzards frequently occur; but in the north the average winter is clear, calm, cold and bright, with a small snowfall. In the south it is much more moderate. June and the first part of July are rainy. Summer is

TABLE III. GIVING ANNUAL AND QUARTELY MEAN TEMPERATURES, DAILY RANGE AND RAINFALL.

	Height above Sea Level	Annual Mean	Winter Mean	Spring Mean	Summer Mean	Autumn Mean	Average Daily Range	Rainfall in Inches
Ontario								
Alton..........	1,300 ft.	41°F	24°F	50°F	60°F	31°F	18°F	37
Goderich........	728 "	45	28	52	62	37	......	32
Galt	880 "	44	26	53	62	35	18	34
Gravenhurst...	750 "	41	21	51	61	31	21	32
Kingston	285 "	42	23	51	63	31	15	34
London.......	932 "	46	30	55	63	37	......	41
Ottawa	330 "	40	19	57	63	28	19	32
Owen Sound...	697 "	43	26	50	62	35	15	39
Parry Sound...	640 "	39	19	40	60	30	18	39
Port Stanley...	575 "	45	29	52	63	37	16	40
Toronto........	352 "	44.1	23.2	40.4	65.4	47	16	34.11
Quebec								
Chicoutimi	150 ft.	34	19	44	61	21	27	24
Quebec City....	296 "	36	14	46	60	24	16	45
Montreal......	187 "	42.1	20	52	63	28	15	40.9
Maritime Provinces								
Fredericton....	140 ft.	40.3	19	49	62	28	19	43.7
St. John.......	Sea level	41	23	47	60	32	16	51
Halifax...	"	43.2	25	46	61	34	16	54.7
Sydney........	"	41	24	42	62	35	16	49
Yarmouth.....	"	43	28	47	59	40	14	52
Charlottetown .	"	40.2	20	44	62	32	14	47.7
Manitoba								
Winnipeg	760 ft.	33.1	3	50	59	27	23	21.39
Edmonton.....	2,158 "	34	3	47	55	32	22	22
Calgary	3,500 "	37.5	14.8	37.8	58.5	38.9	24	14.96
Maple Creek...	2,471 "	41	9	53	63	39	......	......
Banff..........	4,500 "	33	8.5	42.5	51.7	32	......	......
British Columbia								
Kamloops	1,100 "	47.1	26.8	48	66.7	38.8	21	11.46
Spence's Bridge	760 "	48	22	59	68	42	21	11
Victoria.......	Sea level	48.8	36	52	56	45	14	37.7
England								
Birmingham....	....	48	38.4	47.2	57.6	45.5	......	......

characterised by hot days and cool nights, but the warm days of Autumn, often lasting well into December, are the glory of the year.

British Columbia.—There is a great variety in the climate of British Columbia. The south-west is characterized by mild winters, cool, dry summers, south-west winds, and occasional fogs. In the north the winters are severe, and in the interior there are considerable extremes of heat and cold. The rainfall of the interior is light, averaging only 11 inches, while on the coast there is an average of 40 inches.

TRANSPORTATION FACILITIES, ETC.

The slope of the land, eastward from the Rocky Mountains, is so gradual that the rivers flow with an even stream and in an equable volume,—so certain are their sources.

The great Laurentian Lakes, five in number (Superior, Huron, Erie, Michigan, Ontario), form, with their connecting rivers, a complete system of navigation from the head of Lake Superior to the Atlantic Ocean,—a distance of 2,384 miles. They cover an area of about 150,000 square miles. Further north, Canada may be entered by way of Hudson Bay, an inland sea of 350,000 square miles area, and the ocean going ship may reach, at Port Nelson, the outlet of a river system stretching out with few interruptions to the very backbone of the continent, and draining an interior basin over 2,000,000 square miles in extent.

Other great lakes are, Great Bear, 11,200 square miles, Great Slave, 10,100 square miles, Winnipeg, 9,400 square miles, Athabasca, 4,400 square miles.

The great rivers include, the St. Lawrence (with its tributaries, the Ottawa, the St. Maurice, the Richelieu and the Saguenay), the St. John, the Restigouche, the Miramichi, flowing into the Atlantic Ocean; the Mackenzie (with its tributary lakes and its chief affluent, the Peace River, affording with trifling obstacles upwards of 2,000 miles of waterway navigable for steam boats), the Copper Mine and the Great Fish emptying into the Arctic Ocean, the Saskatchewan (affording 1,500 miles of steamboat navigation), the Red, the Nelson, the Churchill and the Albany flowing into Hudson Bay; the Fraser and Columbia emptying into the Pacific Ocean.

This profound penetration and permeation of the country by waterways is the great characteristic of Canada.

TABLE IV. THE GREAT LAURENTIAN LAKES.

Lakes.	Length. miles.	Breadth. miles.	Area, square miles.	Height above sea, ft.
Superior..	390	160	31,[illegible]20	602¾
Huron..	400	160	24,000	576¾
St. Clair..	25	25	360	570¾
Erie..	250	60	10,000	566¾
Ontario..	190	52	7,330	240
Michigan..	345	58	25,590	578¾

COMMERCE OF THE GREAT LAKES.—An idea of the magnitude of the commerce of the great lakes will be given by the following figures:—

"During 234 days of navigation in 1889, tonnage passed through the Detroit River to the amount of 10,000,000 tons more than the entries and clearances of all the seaports in the United States, and 3,000,000 tons more than the combined foreign and coastwise shipping of Liverpool and London.

"Nearly three times as many boats pass through the St. Mary's Falls Canal at Sault Ste. Marie as through the Suez Canal, with an aggregate tonnage of 7,221,935 in 1889, against 6,783,187 for the Suez Canal, though with only 234 days of navigation, whereas the Suez Canal is open all the year round."

TABLE V. DISTANCE BETWEEN PORT ARTHUR, LAKE SUPERIOR AND LIVERPOOL.

Port Arthur and Sault Ste Marie	273	miles.
Sault Ste. Marie and Sarnia	318	"
Sarnia to Amherstburg	76	"
Amherstburg to Port Colborne	232	"
Port Colborne to Port Dalhousie	27	"
Port Dalhousie to Kingston	170	"
Kingston to Montreal	178	"
Montreal to Three Rivers (Tide water)	86	"
Three Rivers to Quebec	74	"
Quebec to Saguenay	126	"
Saguenay to Father Point	57	"
Father Point to West End Anticosti	202	"
Anticosti to Belle Isle	441	"
Belle Isle to Malin Head	2,013	"
Malin Head to Liverpool	221	"
Total	4,494	miles.

ST. LAWRENCE CANAL SYSTEM.—The River St. Lawrence, with the system of canals established on its course above Montreal, and the lakes Ontario, Erie, St. Clair, Huron and Superior, with connecting canals, afford a course of water communication extending from the Straits of Belle Isle to Port Arthur at the head of Lake Superior, a distance of 2,384 miles.

As a great engineering work the St. Lawrence ship channel has special interest. When first undertaken it was considered, of its kind, a work of unusual magnitude, and it is still quoted as one of the great dredging works in the world.

From the Straits of Belle Isle, at the mouth of the St. Lawrence, to Montreal, the distance is 996 miles. From Quebec to Montreal, the distance is 160 miles. Owing to the shallowness of the waters on a portion of the river between these two places, particularly through Lake St. Peter, vessels drawing more than from ten to twelve feet were formerly barred from passage for the greater part of the season of navigation. In 1826, the question of deepening the channel was first definitely mooted, but it was not until 1844 that any dredging operations were begun. In that year, the deepening of a new straight channel was commenced, but the scheme was abandoned in 1847. In 1851, the deepening of the present channel was begun. At that time the depth of the channel at low water was 10 feet 6 inches. By the year 1869, this depth had been increased to 20 feet, by 1882 to 25 feet, and by the close of 1888 the depth of 27½ feet, at low water, was attained for a distance of 100 miles from Montreal to a point within tidal influence. This work is now being continued by the Government of Canada which, in 1888, under the provisions of the Act 51 Vic., ch. 5, of that year, assumed all financial responsibilities. The channel has a minimum width of 300 feet, extending to 550 feet at points of curvature, is lighted and buoyed, and it is expected that the depth of 30 ft. will be attained throughout, during the summer of 1905.

Navigation, which is closed by ice during the winter months (December, January, February, March), opens about the end of April.

Montreal has by this work been placed at the head of ocean navigation, and here the canal systems of the River St. Lawrence begin, overcoming the various rapids by which the river channel above Montreal is obstructed, and giving access through the St. Lawrence canals, the Welland Canal, the great lakes and the Sault Ste. Marie Canal, to the head of Lake Superior.

The difference in level between the point on the St. Lawrence near Three Rivers where tidal influence ceases, and Lake Superior, is about 600 feet.

The Dominion canals, constructed between Montreal and Lake Superior, are the Lachine, Soulanges, Cornwall, Farran's Point,

Rapide Plat, Galops, Murray, Welland and Sault Ste. Marie. Their aggregate length is 73 miles; total lockage (or height directly overcome by locks) 551 feet. The number of locks through which a vessel would pass on its passage from Montreal, at the head of ocean navigation, to the head of Lake Superior is 48. The Soulanges Canal takes the place of the Beauharnois Canal, and the latter may be abandoned for navigation purposes.

Communication between Lakes Huron and Superior is obtained by means of the Canadian Sault Ste. Marie Canal, and also by the St. Mary's Falls Canal, situated on the United States side of the river at St. Mary.

It is important to note that the enlargement of the canals on the main route between Montreal and Lake Erie comprises locks of the following minimum dimensions; length, 270 feet; width, 45 feet; depth of water on sills, 14 feet. The length of the vessels to be accommodated is limited to 255 feet. At Farran's, in the canal of that name, the lock is 800 feet long. A similar lock is built at Iroquois on the Galops Canal, the object being to pass a full tow at one lockage.

TABLE VI. ST. LAWRENCE CANALS.

Name.	Length in miles.	Locks.			
		No.	Rise, feet.	Depth on sill Feet.	Dimensions, feet.
Lachine	8½	5	45	2 locks 18 3 " 14	270 x 45
Soulanges	14	5	84	15	280 x 45
Cornwall	11	6	48	14	270 x 45
Farran's Point	1	1	3½	14	200 x 45 800 x 45
Rapide Plat	3⅜	2	11½	14	270 x 45
Galops	7⅓	3	15½	14	800 x 45 (1) 270 x 45 (2)
Welland	26¾	26	326¾	14	270 x 45
Welland Branches—					
Welland River Branch	⅜	2	10	9-10 ins.	150 x 26½ (1)
Grand River Feeder	21	2	7 to 8	9	150 x 26½ 200 x 45
Port Maitland Branch	1¾	1	7½	11	185 x 45
Sault Ste. Marie Branch	1⅛	1	18	20-2 ins.	900 x 60
Total	73⅜	49			

The Rideau River and Canal system furnishes a continuous water way between Kingston and Ottawa (elevation 250 ft.) through the Rideau Lakes (elevation 404 ft.) and river.

TABLE VII. OTTAWA & RIDEAU RIVERS, CANAL SYSTEM.

Name,	Length in miles	Locks.			
		No.	Dimension Feet	Rise feet	Depth on sill feet.
St. Anne's Lock..........	$\frac{1}{8}$	1	200 × 45	3	9
Carillon	$\frac{3}{4}$	2	200 × 45	16	9
Chute à Bloudcau.........	$\frac{1}{8}$	—	—	—	—
Grenville.	$5\frac{3}{4}$	5	200 × 45	$43\frac{3}{4}$	9
Rideau...	$16\frac{1}{2}$	49	137 × 33	$282\frac{1}{4}$	5
Perth Branch.............	6	2	134 × 32	26	$5\frac{1}{2}$
Total	$29\frac{1}{4}$	59	....	.	....

Besides these larger systems there are many smaller ones, such as the Richelieu and the Trent* which, when completed, will join the waters of Georgian Bay (Lake Huron) with those of Lake Ontario by a route about 200 miles long, of which some 20 miles will be actual canal.

TABLE VIII.

Amount expended on Canal works and maintenance (chargeable to capital) to June 30th, 1903.

Lachine Canal	$11,181,164.00
Beauharnois Canal	1,636,690.00
Soulanges Canal	6,738,643.00
Williamsburg Canal	9,567,077.00
Cornwall Canal	6,963,299.00
St. Lawrence River Canals, Surveys, etc.	2,874,243.00
Murray Canal	1,247,970.00
Welland Canal	24,634,157.00
Sault Ste. Marie, Canal	4,281,465.00
St. Ann's Lock & Canal	1,170,216.00

* The construction of this canal involved some very important engineering work, including a hydraulically operated lift-lock 140′ x 33′ x 8′. The rise is 65′.

Carillion & Grenville Canal	4,182,093.00
Culbute Canal	382,776.00
Rideau Canal, including Perth Branch	4,573,923.00
Trent Canal	4,135,354.00
St. Ours Lock	121,538.00
Chambly Canal	637,057.00
St. Peter's Canal	648,547.00
Lake St. Louis Channel	290,259.00
Lake St. Francis Channel	75,906.00
Total	$85,342,377.00

The following may be taken as a representative of St. Lawrence Canals and is generally conceded to represent a piece of hydraulic engineering of the highest order.

SOULANGES CANAL.

The Soulanges Canal joins Lake St. Francis with Lake St. Louis, two expansions in the St. Lawrence river, and is 14 miles long. The fall of the river at this point, 82½ feet, is overcome by four locks. At the Lake St. Louis end are three locks, each having a rise of 23½ feet. Between the third and fourth locks is an interval of two miles. Throughout, the canal is 100 feet wide at the bottom with side slopes of 2 to 1. There are 6,750,000 cubic yards of clay of all sorts and 300,000 cubic yards of rocks of various kinds in the excavations for the canal. The cost was $6,738,643.00.

The locks are filled and emptied through culverts in the side walls, from which cast iron pipes 30 inches in diameter—ten on each side—lead into the bottom of the chamber. The locks are filled in five or six minutes, without subjecting vessels to much surging or straining.

Advantage is taken of the water power available on the canal to generate electric current for lighting the canal, locks and approaches to the bridges, also to operate the lock-gates, waste weirs and bridges.

The following are the principal dimensions of the canal:—

Length of Canal........................	14 statute miles.
Number of locks (lift)	4
Number of locks (guard)	1

Dimensions of locks	280 ft. by 45 ft.
Total rise of lockage	82½ ft.
Depth of water on sills, ...	15 ft.
Breadth of canal at bottom	100 ft.
Breadth of canal at water surface	164 ft.
Number of arc lamps, (2,000 c.p. each)..	219

THE POWER AND LIGHTING EQUIPMENT OF THE SOULANGES CANAL.

To accommodate the continuously increasing traffic, the Government decided some years ago to light the St. Lawrence Canals, and to operate the locks and bridges by electric power. The lighting allows navigation to be carried on by night and by day with equal facility, lockages being performed as easily and rapidly at one time as the other. By means of the electrical mechanism the lockage may be much more rapidly executed than it could be by hand as, in the latter case, this must be effected by the lockmen laboriously turning the cranks of the winches.

In addition, electrical manipulation requires only about half the number of men needed for hand operation.

The electrical equipment of the Soulanges Canal may be described as an illustration of the methods adopted throughout the system.

Power House.—This is situated five miles from the Lake St. Francis entrance of the canal. At this point the Grease River crosses underneath the canal in a 10 ft. culvert and empties into the St. Lawrence. The water for the turbines is taken from the Canal, the Grease River forming the tail race. The head of water obtained is about 20 ft.

The hydraulic portion of the plant consists of two wheel chambers, in each of which are two pairs of Victor turbines on a shaft which passes through the usual stuffing box into the generator room. To either shaft is directly connected a 2400 volt, 3 phase 264 K.W. 60 cycle, revolving field type generator, operating at 225 R.P.M.

Two exciters are belted to the water wheel shafts.

The switchboard consists of two generator panels, two feeder panels, and one exciter panel, fitted with the usual instruments.

The lighting consists of alternating multiple enclosed arc lamps, placed 480 feet apart on one side of the canal. Each lamp is sup-

plied with current from a 1,000 watt 2080-115 volt transformer. At the locks and bridges the lamps are spaced more closely, and are on both sides of the canal.

HIGHWAY BRIDGES.—The Canal is crossed by seven bridges of 180 feet span, and weighing about 100 tons each. The electrical apparatus for operating these bridges consists of a gear and friction mechanism driven by a two H. P., 220 volt, 3 phase, induction motor placed in a cabin at the centre of the bridge. By a simple movement of a lever in one direction, the bridge can be started, or it can be stopped or retarded by a motion of the same lever in the opposite direction.

LOCK AND SLUICE-GATE MECHANISM.—A three horse-power induction motor is geared to a friction mechanism involving the same principle as that described for operating the bridges. The gates are closed or opened by means of a strut, or drawbar, hinged to the gate under the gate platform, at the end of which is a rack and pinion mechanism worked by the friction apparatus.

The whole machinery is placed in a water-tight, cast iron box, which projects about 15 inches above the coping of the lock.

The system is extremely flexible and is working remarkably well, having been in operation for two years.

SWITCH CABIN.—At each lock there is a switch cabin which contains two transformers for stepping down from 2,200 to 220 volts, the motor voltage. One main switch controls all the motors at each lock.

THE STATEMENTS OF THE ACCOUNTANT AND THE CANAL STATISTICS form two chapters in the annual report of the Department of Railways and Canals. A perusal of these would afford the reader a fairly accurate idea of the cost of the Canadian canals and the revenue derived from them during the last thirty-seven years.

The following table gives a summary of the total freight passing through the canals for the years 1901 and 1902 with the amount of toll collected. The decrease in the tolls is due to their gradual reduction on various articles. All tolls were entirely abolished during the year 1903.

TABLE NO. IX. SUMMARY STATEMENT SHOWING TOTAL FREIGHT PASSING THROUGH CANALS.

Canals.	Tons.		Total Tons.	Amount of Tolls.
	Up.	Do wn		
1901.				
Welland..........	106,405	513,804	620,209	$86 760.48
St. Lawrence......	196,085	1,012,211	1,208,296	97,276 90
Chambly	225,338	134,460	359,798	24,864.52
Ottawa...........	935	444,927	445,862	25,627.19
Rideau	27,106	29,270	56,376	4,114.44
St. Peter's	35,576	52,681	88,257	3,299.12
Trent Valley	25,150	10,382	36,532	1,063.24
Murray..........	15,365	14,170	29,535	1,049.20
Sault Ste. Marie...	661,213	2,159,181	2,820,394	No tolls.
Grand total...	1,294,173	4,371,086	5,665,259	$244,055 09
1902.				
Welland..........	84,754	580,633	665,387	$98,501.50
St. Lawrence......	290,449	802,684	1,093,133	65,081.11
Chambly	266,767	112,675	379.442	22,713.31
Ottawa...........	82	444,600	444,682	24,852.37
Rideau	32,282	18,597	50,879	3,831.15
St. Peter's	31,916	41,622	73,538	3,034.14
Trent Valley......	29,495	12,195	41,690	1,328.98
Murray...........	22,713	12,465	35,178	1,060 80
Sault Ste. Marie...	784,810	3,944,358	4,729,268	No tolls.
Grand total...	1,543,368	5,969,829	7,513,197	$220,503.36

TABLE NO. X. SUMMARY STATEMENT SHOWING THE NUMBER AND TONNAGE OF VESSELS PASSING THROUGH CANALS.

Canadian Vessels.	Total No.	Tons. Up.	Tons. Down.	Total Tons.	Amount of Tolls.
Steam and Sail.					
Welland	1,011	198,473	194,884	393.357	$6,599.77
St. Lawrence	7,416	919,393	771,139	1,690,532	13,760.42
Chambly	1,267	61.852	79,231	141,083	927.69
Ottawa	1.803	42 294	196,988	239.282	2,213.59
Rideau	2 614	80,752	82,587	163,339	1,314.96
St. Peter's	1,664	59,874	54.101	113,975	2,281.34
Trent Valley	2,550	76,014	78.218	154.232	695.94
Murray	793	119,660	103,305	222,965	275.84
Sault Ste. Marie	3,080	700,420	666,510	1,366,930	....
Total Canadian	22,198	2,258,732	2,226,963	4,485,695	28,069.55
United States Vessels.					
Welland	557	207,211	225,155	432,366	6,769.29
St. Lawrence	984	70,258	80,767	151,025	1,031.76
Chambly	2,524	112,246	134,122	246,368	2,961.74
Ottawa	103	2,280	7,895	10,175	2,961.74
Rideau	257	3,190	4 040	7,230	222 99
St. Peter's	7	314	557	871	163.66
Trent Valley	......	....	....	....	17.42
Murray	37	661	371	1,032	....
Sault St. Marie	1,964	1,685,493	1,551,879	3,237,372	8.99
Total United States	6,433	2,081,653	2,004,786	4,086,439	11,175.85
Grand Total, Canadian and United States	28,631	4,340,385	4,231,749	8,572,134	39,245.40

RAILWAYS.

Canada has 167 steam railways. Twenty-five of these have been amalgamated and form the Grand Trunk Railway System. The consolidation of thirty others have produced the Canadian Pacific Railway System. The remaining 112 have more or less consolidated.

The mileage of the chief organizations June 30th, 1903, was as follows:—

Canadian Pacific Railway	7,437 miles
Grand Trunk Railway	3,150 miles
Government Railways	1,519 miles
Other Railways, Bridges and Tunnels....	6,967 miles
Total	19,078 miles

A comparison of the conditions in 1867 with those which obtained June 30, 1903, show:—

TABLE XI.

	1867	1903
Total mileage of track laid	2,087	19,078
Total locomotives	491	2,587
Total cars of all kinds	7,924	85,415
Total passengers	2,784,596	22,148,742
Total freight, tons	2,272,309	47,373,417
Total revenue	$12,029,809	$96,064,527
Total expenditure	$7,953,209	$67,481,524

TABLE XII.

Mileage of track laid in the different provinces and square miles of area to each mile of track in 1903.

Provinces	Miles of track laid 1867	Miles of track laid 1903	Square miles of area to each mile of track in 1903
Ontario..................	1275	7142	30.87
Quebec...................	523	3492	97.87
New Brunswick..	196	1445	19.32
Nova Scotia	93	1050	20.06
Prince Edward Island.......	——	209	10.45
Manitoba..	——	2225	28.91
North West Territory and Yukon Territory............	——	2094	350.11
British Columbia............	——	1421	260.51
Total............	2087	19,078	

GRAND TRUNK RAILWAY.

The Grand Trunk Railway is the pioneer line of the Dominion of Canada, and one of the earliest pioneers of railway enterprise in the whole American continent. The charter of the Grand Trunk Railway was granted in 1851. In 1853, a line from Quebec to Portland, Me., was obtained. The line from Richmond to Levis, 96½ miles, was opened in the following year. The main line from Montreal to Toronto was opened in 1856, and the Sarnia division in 1858. In 1879, the Chicago and Lake Huron line was absorbed into the system. Thenceforth various tributaries and contiguous lines were gradually acquired, until the present Grand Trunk Railway system has a total mileage of 4,182 miles. The Grand Trunk Railway system contains among others, the following objects which are of especial engineering interest. These are:—

(1) The St. Clair Tunnel under the St. Clair River.

(1) The single arch, double track, steel bridge over the Niagara Falls.

(3) The Victoria Jubilee Bridge over the St. Lawrence River, Montreal.

The St. Clair tunnel is under the St. Clair River and connects Port Huron, Michigan, with Sarnia, Ontario. The tunnel proper is 6,026 feet in length, and including the approaches 11,533 feet in length, marking it as the longest sub-marine tunnel in the world. The time of construction was a little over two years, and the cost was about $2,700,000.00. The tunnel was open for freight traffic on October 27th, and for passenger traffic on December 7th, 1891.

The Victoria Tubular Bridge was perhaps, at the time of its completion, in 1860, the greatest engineering work that had been performed in Canada up to that time. This bridge which had become insufficient to meet with the demands of the traffic made upon it, was replaced in 1897-1898, by the Victoria Jubilee Bridge. It is a notable fact that the longest delay in traffic caused by the alterations was only about two hours, and the total length of time that the line was closed during construction was about 20 hours. The following is a synopsis of the dimensions and interesting features of the new bridge:—

Length of steel work, 6,592 feet.

Length including approaches, 9,144 feet.

Number of piers, 24.

Number of steel truss spans, 25.
Length of centre span, 330 feet in the clear.
Length of side spans, 242 ft. to 247 ft. in the clear.
Thickness of centre piers at summer water level, 28 ft.
Thickness of side piers at summer water level, 18 ft.
Material of piers, limestone.
Quantity of masonry, piers and abutments, 100,000 cubic yards.
Height of ordinary span (centre to centre of chords), 40 ft.
Height of centre span (centre to centre of chords), 60 ft.
Width between main trusses (centre to centre), 31 ft. 2 in.
Extreme width of bridge including roadways, 66 ft. 8 inches.
Height of water at centre to underside of bridge, 60 ft.
Grade of trusses to centre, 1 in 130.
Total weight of super-structure, 44,000,000 lbs.
Cost of new bridge, new work, $2,000,000.00.
Cost of old bridge, $7,000,000.00.
Total cost of bridge, $9,000,000.000.

It may be noted in passing that several thousand electrical H P. are transmitted, to be used in Montreal, by wires carried on the top of the bridge.

With the Victoria Jubilee Bridge at Montreal may be classed the Suspension bridge at Niagara Falls, which, yielding to the demands of increasing traffic, has been replaced by a single arch steel bridge. The new bridge is a single arch 550 ft. long, supplemented by a truss span at either end, 157 ft. in length. With the approaches, the total length of the bridge is 1,100 ft. The centre of the arch is 226 ft. above the water. The bridge has two decks. On the upper floor are two tracks for railway purposes exclusively. The lower floor contains a central carriage way, a double trolley track and footpaths on each side. The arch will support on each upper track at the same time, two of the heaviest locomotives, hauling trains weighing 3,500 lbs. to the square foot of bridge surface, and in addition a load of 3,000 lbs. per square foot on its lower floors.

CANADIAN PACIFIC RAILWAY.

The Canadian Pacific Railway is the great imperial highway between Great Britain and her dependencies in the Far East. The construction of the road was first undertaken in 1875 by the Canadian Government. In 1880, however, a charter was granted a syndi-

cate of Canadian capitalists under the name of the Canadian Pacific Railway Company—ten years being the time specified for the completion of the road. In less than five years—and five years ahead of the contract time—the road was built from ocean to ocean, and a regular through passenger and freight service established. The first sod was turned by the company on the 2nd of May, 1881, the last spike driven on 7th November, 1885, and the first through passenger train left Montreal on the 28th of June, 1886. The exact time occupied in building the road from the actual commencement of work was fifty-four months,—two and one-half miles being constructed on an average every day.

The railway system of Eastern Canada had already advanced far up the Ottawa Valley, and it was from a point of connection with this system that the Canadian Pacific Railway had to be carried through to the Pacific Coast, a distance of 2,550 miles. Of this, the Government had under construction one section of 425 miles between Lake Superior and Winnipeg, and another of 213 miles from Burrard Inlet on the Pacific Coast, eastward to Kamloops in British Columbia. The company undertook the building of the remaining 1,920 miles, and for this it was to receive from the Government $25,000,000.00 in money, and 25,000,000 acres of agricultural land. The two sections of railway under construction were to be finished by the Government, and, together with a branch line of 65 miles already in operation, from Winnipeg southward to the boundary of the United States, were to be given to the company, in addition to its subsidies in money and lands.

While the engineers were exploring the more difficult and less known section from the Ottawa River to and around Lake Superior, and marking out a line for the navvies, work was commenced at Winnipeg, and pushed westward across the prairies, where 130 miles of the railway were completed before the end of the first year. During the second year the railway advanced 450 miles. The end of the third year found them at the summit of the Rocky Mountains, and the fourth in the Selkirks, over 1,000 miles from Winnipeg.

In the meantime, independent connections with the Atlantic seaboard were secured by the purchase of lines leading eastward to Montreal and Quebec; branch lines to the chief centres of trade in Eastern Canada were provided by purchase and construction to collect and distribute the traffic of the main line, and other branch lines were built in the Northwest for the development of the great prairies.

The close of 1885 found the company, not yet five years old, in possession of no less than 4,315 miles of railway, including the longest continuous line in the world, extending from Quebec and Montreal across the continent to the Pacific Ocean, a distance of 3,078 miles; and by the mid-summer of 1886, the whole system was fully equipped and fairly working throughout.

The following years were marked by the addition of many lines of railway to the Company's system, and by the establishment of the Company's steamship service to Japan and China. One line of railway was extended from Montreal across the State of Maine to a connection with the railway system of the Maritime Provinces of Canada, affording connections with the seaports of Halifax and St. John; another was completed from Sudbury, on the Company's main line, to Sault Ste. Marie, at the outlet of Lake Superior, where the railway connects with its two important American lines leading westward—one to St. Paul and Minneapolis and thence continuing across Dakota to Portal in the Canadian Northwest, where it again connects with the Canadian Pacific Railway, the other through the numberless iron mines of the Marquette and Gogebic districts to Duluth, at the western extremity of Lake Superior; still another continues the Company's lines westward from Toronto to Detroit, connecting there with lines to Chicago, St. Louis, and all the great Mississippi Valley. Other branches were also built in different parts of Canada, and now the Company's lines embrace over 11,000 miles of railway. The employees of the system number over 40,000.

Marine Services.—The Company did not confine its operations entirely to land. In 1884, a line of steamships was placed on the great lakes between Owen Sound and Fort William; three years later the service to China and Japan was inaugurated, followed by a line to Australia working in connection with the Company. In 1897, the steamships on the inland waters of British Columbia were acquired; in 1902, the steamers of the Canadian Pacific Navigation Company plying on the coast of British Columbia came under the Company's control, and in 1903, the Company's operations were extended to the Atlantic, on which a fleet of 14 steamships was placed. Now the Company's fleet consists of 61 steamships besides 22 car floats and other barges. One can travel from Liverpool to Hong Kong—12,153 miles—more than half way around the globe, on the Canadian Pacific Railway ships and trains.

Equipment.—The progress of the road is shown by the fact that in 1885 the Company's locomotives numbered 336, and in August 1904, there are 1,008; the passenger cars of all kinds then numbered 289, now there are 968; the first-class sleeping, parlour and dining cars have increased from 31 to 167, and freight cars from 7,835 to 31,-980, in addition to which there are 545 conductors' vans, 98 snow ploughs, and 675 boarding and other cars used in the Company's service.

Earnings.—The total earnings in 1885 were $8,368,493.00, of which $2,859,222.00 were from passenger traffic, and $4,881,865.00 from freight, and the total expenses amounted to $5,143,276.00. In 1903 (year ending June 30th), the total earnings had grown to $43,957,-373.00, of which $11,001,973.00 were from passenger traffic and $28,-502,081.00 from freight, and the total expenditure $28,120,527.00. At the present time the earnings are approaching the million dollar mark weekly.

Trains.—An efficient passenger service is run on all the Company's lines. Amongst the fast expresses is the Imperial Limited, which crosses the continent—2,905 miles—in 97 hours. All the through express trains are equipped with sleepers and dining cars. Some of the trains are lighted by electricity, others by acetylene gas. The longest passenger coaches are 79 ft. 10¾ inches, over all, and the longest freight vans are 45 ft. (furniture), 38 ft. 8 in. (refrigerator) and 36 ft. 8 in. (box), with a capacity of from 30 to 40 tons.

Car Shops.—The Company has extensive car shops at Montreal, Farnham, Perth, Toronto Junction, Carleton Place Junction, Fort William, Winnipeg, Calgary and Vancouver. At the three first-named places, car building is largely carried on. The Montreal shops, at which locomotives are also built, are very large, and when the new structures are completed this summer they will be the most extensive on the American Continent. (For details of Montreal shops see page 61.)

Grain Elevators.—The company has also a number of grain elevators with a total storage capacity of 13,530,000 bushels. These are located as follows:—Five at Fort William (capacity 9,200,000 bushels), one at Port Arthur (capacity 780,000 bushels), one at Owen Sound (capacity 1,050,000 bushels), one at St. John, N. B. (capacity 1,000,000 bushels), one at Richford, Vermont (capacity 500,000 bushels).

Hotels.—The Company operates hotels at the following places: —Quebec, Montreal, St. Andrews, N. B., Fort William, Banff, Lake in the Clouds, Field, Lake Emerald, Great Glacier of the Selkirks, Columbia River, Shuswap Lakes, North Bend and Vancouver. To these are to be added hotels at Winnipeg and Victoria, B. C.

Lands.—The Company owns over 18,000,000 acres of land in Manitoba and North West Territories and British Columbia, which is administered by its Land Department with headquarters at Winnipeg. The sales for the year ending 30th June, 1903, were 2,639,617 acres for $9,695,675.

Other Services.—In addition to its own dining and sleeping cars the Company operates its own telegraph, express, hotel and news services. It has also extensive ore smelters at Trail, B.C., and is operating anthracite coal mines near Banff, in the Canadian Rockies.

Table No. 13 shows the amount expended on capital account on railways in Canada. These sums have been devoted by the Federal Government to the improvement of the railway transportation facilities irrespective of the work done by the Department of Public Works.

TABLE XIII. STATEMENT SHOWING AMOUNT EXPENDED ON CAPITAL ACCOUNT ON RAILWAYS.

Intercolonial	$61,923,351.32	
Cape Breton	3 860.679.14	
Oxford and New Glasgow	1,949,063.21	
Eastern Extension	1,324,042.81	
Drummond County	1,464.000.00	$70,521,136.48
Carleton Branch		48,410 48
Montreal and European Short Line		333.942.72
Prince Edward Island		5,429.239.33
Canadian Pacific		62,752.243.58
Annapolis and Digby		660 683.09
Governor-General's car 'Victoria'		1,290.31
Yukon Territory Works (Stikine-Teslin Ry)		283,323.55
Total		$140,030.269.54

ELECTRIC RAILWAYS.

There were, duing the year ending June 30th, 1903, some 45 electric railways in operation in Canada, with a total mileage of 759 miles and a paid up capital of $47,096,453.38. The number of passengers carried was 155,662,812, and the car mileage 38,028,529 miles. The largest systems are:—

Name.	Miles of Rails Laid.
Montreal Street	117.46
Toronto Street	96.74

THE MONTREAL STREET RAILWAY COMPANY.

The Montreal Street Railway Company was one of the first companies on this Continent to change the mode of transportation from horse-power to electric traction. The first electric car was run on their rails in September, 1892. The growth since that time is shown by the following comparative figures:—

	For the year ending Sept. 1892.	For the year ending Sept. 1903.
Receipts of Company ..	$564,406.00	$2,222,787.00
Number of passengers ..	11,631,386.00	71,366,609.00

The chief difficulties which present themselves to electric traction in Montreal are the severity of the grades in many of the streets, and the depth of the snow-fall. Several of the streets have grades of 11 % for considerable distances. An idea of the amount of labour entailed and the expenditure in connection with the snow storms and winter expenses may be gathered from the fact that the average snow-fall for the last twenty winters is about 120 inches per annum.

The company is well equipped with sweepers and ploughs and has demonstrated that a car service can be operated at all seasons of the year, the heaviest snow-falls and blizzards causing only a slight disarrangement of the service.

The cost of the removal of the snow is a large item. During the last winter (1903-4) this amounted to over $200,000.00.

The Company operates about 120 miles of track as well as the 40 miles of track of the Montreal Park and Island Railway Co., which is controlled by the Montreal Street Railway Company. Additions are being made, and it is expected that about 10 miles of track will be added to the system during the present season.

The rails which have been adopted by the Company as standard and are now being used in new work and renewals of track, are of the groove girder type weighing 96 lbs. to the yard, and also 80 lb. "T" rails, and in length of 60 feet.

The trolley wire throughout the city is No. 00, and on the suburban lines No. 0000. The feeders, of which there are about 107 miles, are No. 0000 wire, 250,000 and 500,000 C. M. insulated cables.

The power house is situated on William and Barre Streets. The frontage of the property is 394 feet with a depth of 235 ft. The section used for engines and dynamos is 235 ft. long by 80 ft. wide, and contains six Corliss compound condensing engines of 650 H.P., each belted to generators; one Corliss compound condensing engine 3,400 H.P., directly connected; two Corliss compound condensing engines 1,600 H.P., each directly connected.

Perhaps the most interesting feature of this department is the switchboard 90 ft. long and 20 ft. high.

In addition to the above the Company is supplied 5,000 H.P. by the Montreal Light, Heat and Power Company from their generating plant at Chambly, 17 miles from Montreal. (See page 30). The current is transmitted from Chambly as 25,000 volt, three phase, 66 cycles, alternating current. To convert this to D. C., which is used on the Street Railway system, are employed six direct current, induction motor, generator sets, each having a rated capacity at the direct current end of 500 K.W.

This interesting plant is in a building 90 ft. long and 40 ft. wide, connected to the main power house.

The boiler house contains 16 Lancashire boilers, 250 H.P. each; 6 Lancashire boilers, 300 H.P. each; 6 water tube boilers, 250 H.P. each.

The Company has mechanical wood-working and electrical shops covering an area of 77,000 square feet, where old cars are overhauled and new cars built as required.

The rolling stock of the Company consists of upwards of 800 cars, including sweepers and ploughs, all of which have, with but few exceptions, been built by the Company.

TELEPHONE SYSTEMS.

There are in Canada at the present time upwards of 50 telephone companies. The miles of wire in use during 1903 were 163,242 and the approximate number of messages sent during the year ending June 30th, 1903, was 254,973,750.

By far the most important company is the Bell Telephone Company of Canada, Ltd. This company, whose head office is in Montreal, was incorporated in 1880 by special Act of Parliament with a capital of $500,000.00. The growth since that time is shown by the following table:—

Year.	Capital.	Exchanges.	Subscribers.	Miles of L. D. Line
1880	$ 500,000.	32	2,000	
1885	1,200,000.	175	9,614	3,000
1890	1,494,000.	368	19,350	8,228
1895	3,168,000.	613	28,809	14,851
1900	5,000,000.	837	38,360	21,350
1904	6,000,000.	1,093	57,172	30,969

Canada has been called the birthplace of the telephone, and has kept pace with all the advantages in the art of telephoning. Metallic trunk lines between towns in Ontario and Quebec were erected and put into operation when the system was first introduced in the United States, and the best and most modern switching and signalling appliances have been furnished. This ensures to the public a most reliable service.

TELEGRAPH SYSTEMS.

There are three chief telegraph companies in Canada:—The Great North-Western, the Canadian Pacific, and the Western Union.

	Miles of Line.	Miles of Wire.
Great North-Western	17,838	34,705
Canadian Pacific	10,016	45,886
Western Union	2,632	9,843
Total	30,486	90,434

Number of messages sent in 1902, 5,313,800.

ELECTRIC LIGHT COMPANIES IN CANADA.

In the 315 establishments of 1903 there were 1,786 employees and an invested capital of $20,000,000.

The total number of arc lamps in 1903 was 14,780.

The total number of incandescent lamps in 1903 was 1,212,681.

POWER DEVELOPMENT.

The many rivers and streams in Canada offer, especially throughout the eastern portion, abundant opportunity for the development of water powers. Many of the water falls in the vicinity of manufacturing centres are already utilized for power purposes, but by far the larger number of falls wait for further manufacturing requirements and further growth of the country before development. The heads of water utilized vary from 6 ft. to 265 ft. in height.

Generally speaking, with heads under 20 ft., the power is developed by a series of turbines, so geared to a line shaft as to obtain the speed required for a generator. At Peterboro', Ont., there is, however, a plant operating under a head of 14 ft. or less, with generators directly connected to the turbine shaft. This is the only instance in Canada of generators being connected directly to the turbine shaft at so low a head. In this case, six turbines divided into three pairs are connected to each horizontal shaft.

When the head is above 20 ft., the generators are usually directly connected to the turbine shaft, obviating the necessity of gears and belts.

Most of the directly connected installations in this country are of the horizontal type, but in the case of two of the large Niagara Falls developments, the shafts will be vertical with the dynamos placed on their upper ends.

The following descriptions serve as examples of some of the water power developments in Canada; those selected being good representatives of the class to which they respectively belong. The descriptions refer only to hydraulically operated electrical plants for transmission purposes; but as Canada abounds in water powers, it must be understood that many large flour mills, saw mills and manufactories of all kinds are driven by water power—a notable instance of which may be seen at the Chaudière Falls at Ottawa.

The water power developments are so numerous and increasing in number so rapidly, that it is impossible to give accurate figures showing the total power developed throughout the country.

MONTREAL LIGHT, HEAT & POWER COMPANY'S SYSTEM.

Power is supplied to the City of Montreal from three generating stations, known as the Lachine, Chambly and Shawinigan power houses, located at distances of 5, 17 and 85 miles respectively from the Lachine, Chambly and Shawinigan power houses, located at the city. The voltages used for transmitting energy over these distances are, 5,000 vols, 25,000 volts and 50,000 volts. The rivers supplying this power are the St. Lawrence, Richelieu, and St. Maurice. The drainage areas of these rivers being the great lakes, for the St. Lawrence; Lake Champlain gathering waters from the Green and Adirondack mountains supplies the Richelieu; while the St. Maurice drains an area of approximately 18,000 square miles, consisting almost entirely of forest lands to the north of the St. Lawrence.

The Montreal Light, Heat & Power Company now controls the entire supply of gas and electric energy in the city and its suburbs.

Perhaps the most notable feature in the operation of the system of this Company, is the high load factor obtained. The minimum load factor over 24 hours per day during the summer months is 74%, and during the winter months 76 to 77%, giving an average of about 75% for the whole year. The total out-put for the year 1903 is in the neighbourhood of 85,000,000 K. W. hours.

The company owns and operates two out of the three generating stations supplying power to the city, viz., those at Chambly and Lachine.

The Chambly power house, which obtains its power from the Chambly rapids on the Richelieu river, is 308 feet long by 50 feet wide. The hydraulic equipment of this plant is designed for the development of 23,500 electrical horse-power. There are eight main units, each consisting of 4-51 inch turbines mounted on a horizontal shaft for directly connecting to the A. C. generators. The wheels are mounted in pairs and are set in 15 foot penstocks over draft tubes 10 feet in diameter, 15 feet above tail water and are operated under a working head of 33 feet. There are two smaller units, each consisting of two, 27 inch turbines set in 8 foot penstocks, the same distance above tail water as the larger units. These are used to

drive the exciters for the A. C. generators. Directly connected to each of the large water wheel units is a 2,200 K. W., 152 R. P. M., 2,200 volt, 66 cycle, 2 phase generator. Four of the generators are of the revolving field type, and four of the induction type.

The two exciters are each of 300 K. W. capacity at 125 volt, and run at a speed of 250 R. P. M.

By means of step-up transformers, the voltage is transformed from 2,000 volts, 2 phase, to 25,000 volts, 3 phase at which voltage it is transmitted to Montreal.

Lachine Rapids on the St. Lawrence River between the Island of Montreal on the south bank of the river, is the site of the 2nd named power station.

At this station the working head of water on the wheels is between 16 and 17 feet, and is obtained from an unusual construction. The St. Lawrence River at the point where the power house is located passes through a series of rapids. In order to render a portion of the water available for power purposes, a large break-water was constructed, a mile and a quarter in length, running parallel to the shore and at a distance of 1,000 feet from it. At a point about two-thirds of the way down from the up stream end of the break-water, the power house (1,000 ft. by 50 ft. wide) is built between the shore and the break-water. The present hydraulic equipment of this station is for 8,000 electrical horse-power, and consists of eight units, each unit being made up of six vertical turbines of 51 inches diameter, connected to a jack shaft by means of crown gears and pinions; all are controlled by governors. To each water wheel unit, consisting of six wheels, is connected a 750 K. W., 60 cycle, 3 phase, 5,000 volt, revolving field generator, the normal speed of which is 180 R. P. M. To supply the necessary exciting current for the A. C. generators, there are four exciters each rated at 75 K. W. at 120 volts. The exciters are driven at a normal speed of 660 R. P. M. by a belt from a separate water wheel.

There are at the present time five sub-stations distributing power to the city and suburbs. The principal ones (central station, McCord St. sub-station, and the Shawinigan sub-station) are tied together by means of a 2,200 volt tie line. At these three sub-stations, the energy received from the generating stations is transformed and converted to alternating current at 2,400 volts, 60 or 63 cycle, 2 or 3 phase.

Besides these water power plants, the Company has several steam plants located at different points throughout the city. These plants which are used as reserves, have a total capacity of between 7,000 and 8,000 electrical horse-power.

THE SHAWINIGAN WATER AND POWER COMPANY.

These works are located at Shawinigan Falls, Province of Quebec, on the St. Maurice River. The total fall in the river occurring at this point is about 150 feet.

The St. Maurice River above Shawinigan Falls drains a tract of country reaching north to the divide between the St. Lawrence and Hudson Bay Valleys, and extending from Lake St. John on the east to the sources of the Gatineau, an area of upwards of 18,000 square miles. The country is heavily wooded and thickly interspersed with lakes.

The snow in winter covers this country to a considerable depth, and reaching as far north as it does, the effect of the melting snow does not cease to be felt at Shawinigan until late in June. The numerous lakes store the waters to such an extent that the flow of the river is very regular and seldom falls below 10,000 feet per second, which, under the available head of about 140 feet, is sufficient to produce upwards of 100,000 horse-power.

In making the power development at Shawinigan, the water is taken out of the river by means of a canal—about 1,100 feet in length, 100 feet wide and 20 feet deep—to the gate-house. From here the water is taken to the power house by means of penstocks. There are at present installed in the main power house, three pairs of turbines, one connected directly to each of the 9 foot penstock pipes. These turbines each consist of a pair of inward discharge wheels in a steel case, operating at 180 revolutions per minute and capable of delivering 6,000 horse-power. There is directly connected to each of the three wheels a generator of the revolving field type of 3750 K. W. capacity, generating 30 cycles, two phase, 2,200 volt current. The water wheels have generators operating on a horizontal shaft, and are set in two lines in the power house, the shafts extending lengthwise in the power house and the units staggered.

A fourth unit is now being installed which will have a water wheel of a capacity of 10,500 horse-power, taking water through a penstock 12 feet in diameter now being constructed.

Two 500 horse-power wheels are each connected to a direct current generator of 400 K. W. capacity at 125 volts. These are used as exciters.

The current from each generator is conducted to the generator switch by paper-insulated, lead covered cables. These cables pass from the oil switches to a selector switch, by means of which the current can be thrown on to either one of the two sets of busbars, the plan being to separate the load which is subject to fluctuations, from the more steady load, by means of two sets of busbars. From the busbars the current for local small power works is conveyed on lead covered cables at 2,200 volts to a lightning arrester house, and thence on over-head lines to the points of use. The current for larger factories, located two miles or more from the power house up to a distance of 20 miles, is conducted from the busbars through oil switches to step-up transformers, stepping up to 25,000 volts, two phase, and thence through lightning arresters and over-head lines to the points of use. The current designed for greater distances is taken from the busbars through oil switches to the transformers and changed to three phase, passing through the static interruptors and lightning arresters to the over-head lines.

The transformers are of the oil insulated, water cooled type, having a rated capacity of 1,110 K. W.

The total length of the transmission line from the generating station, Shawinigan Falls, to the terminal station in Montreal, is 84.3 miles. The transmission lines consist of three aluminum cables, each composed of No. 7 aluminum wire. The total drop in the transmission line when 8,000 H. P. are being delivered to the customers' busbars in Montreal is, at unity power factor, about 18% of the delivered voltage, requiring about 50,000 volts for the generating station. By operating at a higher drop, considerably more power may be transmitted over the lines, and it is possible to do this with the present installation, since the step-up transformers are capable of operating at considerably over their rated voltage.

The three line cables are arranged in an equilateral triangle, the distance from centre to centre of the cables being 60 inches.

A second transmission line is now being constructed, similar to the one described, except that the cables will be composed of seven strands of No. 4 wire.

The step-down transformers in Montreal are of the same type

as the step-up transformers, being 1,000 K. W. in capacity and designed to reduce the current from 44,000 to 2,400 volts, three phase.

At Montreal the Company has contracted to deliver to the Montreal Light, Heat & Power Company, current at 60 cycles. Motor generators are installed to change the frequency. There are at present installed five of these sets of a normal capacity of 800 K. W. These consist of a three phase, 30 cycle, 2,400 volt, synchronous motor directly connected to a three phase, 2,400 volt, 60 cycle generator. Each set has mounted on the same shaft exciter for the whole set which is also used as a starting motor. The current for starting is taken from an auxiliary set consisting of a 75 K. W., compound wound, direct current generator, directly connected to a 30 cycle, three phase 2,400 volt motor. This small motor generator set may be used as an exciter for any set in case of accident to the directly connected exciter.

There is now being installed a set having a capacity of 4000 K. W., similar in all respects to those described above.

It is intended to deliver current from Shawinigan, not only to Montreal, but to other towns between Shawinigan and Montreal. One branch has already been built. This branch transmission line crosses the St. Maurice River by means of sub-marine cables. The transmission voltage is 12,500.

The total amount of power now being delivered in Montreal from Shawinigan, is something over 6,000 horse-power.

POWER DEVELOPMENTS IN THE NIAGARA DISTRICT.

There are three large power developments under construction at Niagara Falls at the present time, viz., The Canadian Niagara Power Company, the Ontario Power Company, and the Toronto & Niagara Company.

THE CANADIAN NIAGARA POWER COMPANY is working in conjunction with the Niagara Company on the American side of the falls, and their constructions and operations have been developed from the experience of that Company. They are constructing works designed for a capacity of 110,000 H. P.

The tail-race is 2,200 feet long and of horse-shoe form, 25 feet high and 19 feet wide, being lined with 17 inch concrete, with vitrified facing. The grade of this tunnel is seven feet per 1,000, which will give a speed of water when the plant is in full operation of about 27 ft. per second.

The head canal has a clear waterway 15 ft. deep and 250 ft. wide. This canal widens into a forebay 600 ft. wide, extending the whole length of the power house. The power house is protected from ice by means of racks, submerged arches and over-flow weir.

The wheel pit is 165 ft. deep, 18 ft. wide inside, and 570 ft. long. The turbines are in five units 12,500 H. P. capacity each. They are of the twin, vertical type, inward discharge, two draft tubes to each unit, discharging into the open tail-race below.

The generators, each of 10,000 H. P. capacity, are of the internal revolving field type and will generate alternating three phase current, 25 cycles, at 12,000 volts. The generators and turbines are directly connected by a vertical shaft and will revolve at 250 R. P. M. The auxiliary machinery, consisting of exciter turbines, exciters, water pumps, oil pump and oil tanks, etc., are placed in three chambers built into the side of the wheel pit, 100 ft. beneath the surface. The transformer station is equipped with water cooled transformers.

The Toronto and Niagara Company have adopted a construction similar to that of the Canadian Niagara Power Company, having a wheel pit 158 ft. deep by 416 ft. long, excavated in the solid rock, and the discharge of water therefrom effected by a low level tail-race tunnel running under the centre of the bed of the river and discharging directly under the centre of the Horse-shoe Falls. This development is accompanied by some daring examples of hydraulic engineering for, while ordinary engineering difficulties are met with throughout the work, those encountered in connection with the gathering dams and the head race and the discharge portal underneath the centre of the falls, are such as to astound the most courageous engineer.

The wheels, of which there will be 11 of 12,500 H. P. each operating under a head of 143 ft., will drive, through their vertical shafts, 10,000 H.P., 25 period generators. The vertical shafts attached to these turbines will have a length of 115 ft. each, supported at three intermediate points by bearings placed on solid masonry. On a basis of 125,000 H. P. developed and an efficiency of 80%, the requirements of this plant will be about 66,000 cubic feet of water per minute. It is the intention to transmit the electrical power to Toronto at about 60,000 volts.

THE ONTARIO POWER COMPANY has adopted a different method of dealing with the hydraulic part of their plant. This Company is bringing the water from Dufferin Island in three steel pipes, each 18 ft. in diameter, 6,000 ft. long, buried underneath the ground, delivering this water at their power house situated below the falls in the gorge, and discharging their tail-water into the river immediately below the power station. When working at full capacity the velocity of the water in these 18 ft. pipes will be 15 ft. per second, and each pipe will develop 50,000 H. P. It will readily be seen that important engineering problems arise in connection with the sudden variation in the water supply required by the turbines, when pipes 6,000 ft. long are supplying water at such a rapid rate of flow. Their head works has an ultimate capacity of 200,000 H. P., and this is nearly finished. The total amount of power which the Company is privileged to take under terms of their contract is 100,000 H. P. The turbines which will be of the horizontal type, two runners on each shaft, discharging into a central straight tube will operate under 175 ft. head at 187½ R. P. M., each unit developing 11,300 H.P.

At De Cew Falls between Niagara and Hamilton, is located the power station of the HAMILTON CATARACT POWER, LIGHT & TRACTION COMPANY. This plant has been in operation for some time, and at present is being extended. The power is chiefly used in the city of Hamilton, 34 miles distant from the power station, for the supply of the city lighting and for operating machinery, electric railways, etc., which centre there.

The Cataract Power Company takes its water from the old Welland Canal through a weir built by them for that purpose, under contract with the Dominion Government. It passes thence through about ½ mile of canal of rectangular section 40 ft. by 9 ft. At the lower end of this canal the water carrying capacity amounts to about 1,200 cubic feet per second. The water discharges into a series of basins or lakes, formed by damming up two ravines by heavy earthern embankment constructions. The area of the lakes amounts to 409 acres at mean water level; the depth of water varies from 8 ft. to 40 ft. at the lower dam. The total development is intended to produce 40,000 H. P.

The Company is constructing a forebay, 265 ft. head, through which six penstocks, 6 ft. 6 ins., internal diameter pass. These penstocks, which are 800 ft. long, each supply one 6,300 H. P. single runner, double discharge horizontal turbine running at 286 R. P. M.,

directly connected to a 5,000 K. W., three phase, revolving field, 2,400 volt, 66⅔ period generator, excited by two water driven K. W. exciters and 4-100 K. W. induction motor driven exciters. The old part of the power house contains 2-1,000 K. W. and 2-2,000 K. W. alternators, all directly connected to suitable water wheels.

The transformers are of the oil insulated, water cooled type with the usual controlling and protective devices, and transforming from 2,400 primary to 22,500-45,000 volts for transmission purposes.

The transmission lines are as follows:—

No. 1, line consists of 3-380,000 C. M., aluminum cables arranged in a 44 inch equilateral triangle. Lightning protection is attempted by means of barbed wire stretched in the centre of the triangle.

No. 2, line consists of 6-No. 000 copper conductors arranged in two right angle triangles with 56 inch base and perpendicular.

It is expected that the voltage distortion due to this unsymmetrical arrangement will not exceed 3% with full non-inductive load.

This Company operates practically all the factories in the city of Hamilton. It also owns and operates the Hamilton Radial Electric Company, the Hamilton Street Railway, and Hamilton & Dundas Street Railway, the City Street Arc Lighting & Commercial Lighting. It lights several other towns in the district, and supplies power to the local Company furnishing light and power in the city of St. Catherines.

THE POWER DEVELOPMENT AT SAULT STE. MARIE.

The power development at Sault Ste. Marie consists in the utilization of about 6,000 cubic feet of water per second, with an effective head of about 19 feet (approximately 13,000 H.P.). The diversion of the water is by a canal of about 750 square feet section and about ¼ mile long. This canal is guarded by timber gates and terminates at the power house. The turbine installation is in 250 H. P. units on vertical shafts. Power is utilized for operation of pulp grinders and electrical apparatus.

THE POWER DEVELOPMENTS OF THE OTTAWA DISTRICT.

The district surrounding the city of Ottawa has many water powers. It has been estimated that within a radius of about fifty miles from the city may be found water powers aggregating 500,000

H. P. at low water. Few, however, of the falls have been utilized for power developments. The principal falls with the approximate power that might be developed at each are as follows:—

Chaudière Falls..	drop,	40 ft.	
Little Chaudière..	"	10 "	20,000 H. P.
Chat's Falls..	"	40 "	75,000 "
Portage du Fort..	"	15 "	25,000 "

all on the Ottawa River.

High Falls on the Lièvre River, 180 ft., 82,000 H. P.

THE OTTAWA ELECTRIC COMPANY.

The equipment of the central station at Ottawa includes three generating units of 1,000 H. P. each with provision for a fourth unit. The generators run at 180 R. P. M., and produce 2 phase, 2,300 volts, 60 cycles, alternating current. These are directly connected to turbine sets mounted on the same horizontal shaft as the generator. The working head is 25 to 28 ft. The generators supply current directly for incandescent lighting and for power to induction motors. The direct current power, at 500 volts, is supplied through a rotary converter, and the street arc lamps are operated by current from six multi-circuit arc generators driven in pairs by directly coupling to 2 phase induction motors.

THE OTTAWA ELECTRIC RAILWAY COMPANY.

The generating equipment of the Ottawa Railway Company consists of a single unit of 1,200 K. W., running at 600 volts, supplemented by a storage battery of 268 chloride cells of a capacity of 1,000 ampere hours, with booster, floating on the system. The generator is directly connected to 6 wheels mounted on one horizontal shaft. The working head is 20 feet. The power is used for street railway services.

Among other power developments in the vicinity are the Ottawa Power Co., Deschesnes Elecric Co., the Capital Power Co., the Ottawa & Hull Power Manufacturing Co., Ltd., the Consumers Electric Co., etc.

THE QUEBEC RAILWAY, LIGHT AND POWER COMPANY.

The power development of the Quebec Railway, Light and Power Company is situated on the Montmorency River, some seven miles from the city of Quebec. The fall in the river at this point is about 267 feet. The head utilized, however, is only 200 feet, previous rights preventing the utilization of the total head.

The water is taken from the forebay, above the falls, by means of an intake pipe 9 ft. in diameter and thence to the power house by means of feeder pipes, 2,609 feet long, which latter conform somewhat to the irregular hillside. To protect the pipes from the effects caused by the variation in flow of the water due to the fluctuating load on the generators, stand pipes are erected.

There are five turbines installed in the power house, each having a capacity of 1,000 H. P. under a head of water 200 feet high. At an official test one of these turbines, at half gate, gave an efficiency of 78 per cent. Each horizontal turbine shaft is coupled directly to the generator shaft.

The generator equipment includes 3-600 K. W. and one 720 K. W. two-phase, 66 cycle, 5,500 volt alternators and one generator delivering 550 volt direct current from one end and two phase alternating current at the other end. Two D. C. generators are separately driven for excitation purposes.

The transmission line is taken across the St. Charles River by means of two iron towers 150 feet in height. Lightning protection is afforded by means of barbed wires and lightning arresters.

The sub-station in Quebec is equipped with 10 water cooled, and 4 air cooled, oil transformers. These reduce the voltage from 5,000 to 2,000 volts. The sub-station equipment also includes two synchronous motors directly connected to 4-125 light, arc machines, 2 motor generators and 2 exciters directly connected to two induction motors, step-down transformers for the starting and exciter motors, switchboard, etc.

The electrical current is used for lighting and railway service.

INDUSTRIAL CANADA.

The industries of Canada fall into five leading groups :—agriculture, fisheries, mining, lumbering and manufacturing.

AGRICULTURE.

About 45% of the population of Canada is supported by farming. In addition to this there is a large class employed in industries arising out of farming, such as flour, oatmeal, milling, pork and beef packing, and cheese and butter manufacturing. Agriculture is thus the paramount industry in Canada. It was estimated in 1902 that, of the wheat raising land in Ontario, Manitoba, New Brunswick and the North-West Territories, 4,215,197 acres were tilled for that purpose, while the area of Athabaska, Manitoba, Assiniboia, Saskatchewan and Alberta is calculated at 384,724,429 acres. At the very least 100,000,000 acres of that land will grow Manitoba No. 1 hard, and at a low estimate of 15 bushels an acre could produce 1,500,000,000 bushels. Great Britain imports about 180,000,000 bushels of wheat.

The following comparative statement of the value of exports of some of the farm products of Canada during the years 1893 and 1903 shows the growth in that period and indicates somewhat the possibility for the expansion of that trade.

TABLE XIV. VALUE OF SOME CANADIAN FARM PRODUCTS EXPORTED IN THE YEARS 1893 AND 1903.

	1893.	1903.
Wheat	$7,060,033	$24,566,703
Flour	1,741,028	4,699,143
Oats	2,553,910	2,583,151
Oatmeal	625,977	537,002
Pease	2,441,434	1,052,743
Cattle	7,745,083	11,342,632
Cheese	1,340,740	24,712,943
Butter	1,296,814	6,954,618
Meats	3,132,576	17,116,933
Eggs	868,007	1,436,130
	$40,846,602	$95,001,998

The wheat produced per acre varies from 10 to 26 bushels depending upon the season.

In 1901 in Manitoba the yield was 25.1 bushels per acre.
In 1902 in Manitoba the yield was 26.0 bushels per acre.
In 1903 in Manitoba the yield was 16.4 bushels per acre.
In 1901 in North-West Territories the yield was 25.37 bush. per acre.
In 1902 in North-West Territories the yield was 22.3 bush. per acre.
In 1903 in North-West Territories the yield was 19.14 bush. per acre.

A summary of this yield of wheat, oats, and barley in the provinces of Ontario, Manitoba, New Brunswick, and the North-West Territories in 1903 shows :—

	Acres.	Bushels.
Wheat..	4,215,197	78,495,742
Oats..	4,118,967	163,235,189
Barley..	1,109,463	35,034,010

In 1903 Canada was the tenth largest wheat producing country in the world. The total wheat grown in 1903 in the world was 3,009,810,000 bushels, of which Canada produced 81,810,000 bushels.

One of the great transportation problems in Canada is the moving and storing of the wheat, in its progress from the field to the market. The following sketch describes how both are accomplished.

GRAIN ELEVATORS.

The grain elevator as one finds it to-day in operation in all the great trading centres is, comparatively speaking, a novelty. There has been in the last quarter century a radical change in the conditions attending the grain-growing industry, and the problems of transportation and handling of the grain are not older than the new conditions which give rise to them. The manner in which they have been met, the ingenuity, the economy of effort, with which the hundreds of millions of bushels of grain are every year moved from point to point, stored and shipped again, are perhaps matters of interest to others than those directly concerned with them. The purpose of this, therefore, is to present, not at all in a technical way, some of the devices for the swift and economical manipulation of grain which are embodied in the modern American elevators.

What complicates the problem is the lack of co-ordination between the demand and the supply. The wheat is not for the consumption of the men who raised it, nor for their neighbours. It is sown, harvested and carried away in freight cars without anyone being able to guess its ultimate destination. It must go here and there, from this storehouse to that, until the telegraph or cable reveals where it can finally be disposed of to the greatest advantage. Part of it finds its way into the holds of steamships that carry it to Europe.

What the grain will cost when at last it is converted into food will depend largely on the expense with which all this necessary

manipulation is accomplished. Its bulk is so great in comparison with its value, the industries incident to its handling are on so vast a scale, that every device which saves time or energy, even a little, assumes the first importance. Man-power is too costly even to be thought of now-a-days, so, through a thousand mechanisms simple or elaborate, the cheaper power of steam has been applied everywhere. Steam takes the grain from the cars, stores it in bins, lifts it high in the air and lets it come whirling down through great spouts into the holds of ships.

And to illustrate the manner in which these things are accomplished, we shall follow through the succeeding pages the course of the grain from the western prairie across the Dominion to the sea.

The beginnings are simple enough; farmers' waggons loaded with wheat, jolting along a rutty road to the nearest railway siding. Here stands what is called the receiving house, the primitive grain elevator. It is a tiny affair, considering the ground space it occupies. The typical one will be 20 x 24 feet, but it runs 45 feet up into the air.

The waggon is driven up an incline into the building, and after weighing is halted over the dumping sticks, by means of which the fore wheels are raised and the hinder ones depressed, so that the wheat falls out of the back of the waggon through a trap in the floor. Then it is tumbled into the boots of an elevator leg.

The leg is the device that is used in all grain elevators, large and small, for lifting the grain. It consists essentially of two pulleys, one in the boot, the other at the head, over which runs a belt, generally of rubber. At regular intervals along the belt metal cups are attached, and, as the pulleys revolve, these cups scoop up the grain from the boot and carry it to the head where it is turned out, by the inversion of the cups, into a spout placed there to receive it. In an elevator such as the one under consideration the leg will carry up a thousand bushels an hour. The legs in the great elevator at Manchester will lift ten times as much, but the principle of operation is exactly the same.

In this receiving house the leg carries the grain to the top of the building whence it passes through spouts into the bins. The bins (there are four of them) are ten or twelve feet deep; they are the greater part of the building.

When the freight cars that are to carry away the grain are shunted upon the siding, the grain is drawn from the bottom of

the bins, lifted again to the top of the house where it is weighed in hoppers, and spouted into the cars.

That is not intricate. It has been dwelt upon so fully here because these are the essential operations of all grain elevators; up by steam power and down by gravity, into the little bins and out of them again; that is the important part of the story, whether your bin is meant to accommodate five thousand bushels or two millions.

When our grain laden freight cars are hauled off the siding again, they may be bound for any one of a number of our big interior elevators, say Fort William or Port Arthur. In any case, they will fall in with thousands of other cars just like them and they will be jostled and bumped and shunted until at last they roll into a great structure three hundred feet long, covered with corrugated iron, brick or tile.

This is the warehouse for grain—the elevator—designated by a registered title, inspected and licensed by the government and under the more particular supervision of the city Board of Trade. Grain must be weighed and classified before going into its bins, and once there it is as easy to deal in it in the market as it is to transfer money in a bank from one account to another. The warehouse receipt for it is negotiable; to all intents and purposes it is the grain itself.

In the elevator the cars are not allowed to wait long. They have come into the electrical atmosphere of hurry which pervades the world of commerce. Time and space are almost priceless, so the seals are broken and the car doors rolled back, and then in a moment the grain first makes its acquaintance with the power shovel :—

The power shovel is a most ingenious drum situated on a revolving shaft. A rope is wound upon this drum, and if you take hold of the end of it and walk away, it will unwind easily and as far as you please, so long as you do not stop. The moment you do stop, however, it will wind up again and haul you back to the point you started from. A big iron shod two-handled scoop is attached to this rope, and with it the shoveler goes into the car. The moment he stops the rope jerks taut and a scoop full of grain is drawn out of the car and dumped into the boot of an elevator leg. A pair of shovelers—they work in pairs—can take out of cars about thirty thousand bushels a day.

Now we tell again the story of the tiny receiving house on the prairie, for the grain goes up the leg and is spouted into the bins just as it was before, but with this important variation that instead of one leg there are sixteen; the cups they carry that were eight inches wide are twenty, and the four bins for the spouts to fill have grown to more than a hundred.

We have spoken of bins before, but they are worth mentioning again for they are, after all, the most distinctive feature of the American method of handling grain. In European warehouses, so generally that the exceptions are inconsiderable, the grain is spread, three feet deep, perhaps, over immense floors; but the American elevator turns to the vertical dimension instead of the horizontal, and the grain is piled sixty feet high in narrower bins. The greatest of them is not likely to be more than sixteen feet square. The sides and the bottom, which instead of being square is tapering so that the bin will drain perfectly, are made of cribbing, planks two inches by four at the top and increasing to two by ten at the bottom, nailed broad sides together.

How long our grain will lie in these bins depends upon luck or circumstances.

But we have predestined that our grain shall cross the sea, so at last, when what is beneath it in the bin is drawn away and other grain is piled above it, its time comes to escape through the open door at the bottom and then be lifted in the now familiar way by the tireless metal cups and to take again the swift plunge down a big spout. The grain that left the bin just ahead of it may have been turned into freight cars and sent off to almost anywhere, but ours is for Depot Harbour, Ontario, and the spout directs it down, far down, into the hold of a vessel.

She is a clumsy steam barge, blunt nosed, broad beamed, her single funnel located far aft. She stood high out of water at first, but before the great yellow streams have been pouring through her hatches two hours she has settled lower and lower into the water and is ready to cast off and plod, twelve knots an hour to Depot Harbour.

Other prows are pointed thither, and when we reach this next stopping place in our journey to the sea it needs but a glance at the crowded shipping, the other vessels, grain laden like ours waiting their turn alongside the great elevator to which our cargo is

consigned, to convince us that here, as at Port Arthur a single hour's delay will prove costly.

Obviously, too, here is a new problem to solve. The power shovel which made such short work of the freight cars will never do for lifting the grain straight out of our deep hold and through our narrow hatches. Well, we shall see. We are moved close by the elevator, our main hatch exactly opposite a tower-like structure built right against its side and a single story higher than the rest of the building.

Inside of this marine tower, as it is called, hangs a huge affair framed of steel and timbers, booted and sheathed with iron, and we have not long to wait here beside the elevator before this monster descends, slowly and with dignity befitting its size, but still in the most matter-of-fact sort of way. A big stick of timber with a roller at the end of it is run out from below and pushes the booted end out away from the side of the elevator until it hangs directly over the opening to our hold. Then down through the hatchways, until the boot is hidden in the grain.

The problem has been solved, you see, and this time by sheer audacity. For do you recognize this thing that is plunged into our hold ? The five thousand bushels of wheat that we have accompanied so far recognize it at once. They were lying near the top of the pile and in just twenty minutes the last of them tumbled into the boot and was lifted just as it had been so many times before. For what we have been watching is nothing but an elevator leg hung up bodily in the marine tower ; it is ninety feet long, and it can be let down and pulled up nearly fifty feet if necessary. It will lift fifteen thousand bushels an hour out of the hold and into the elevator.

We have said that before the grain goes to the bins it must be weighed, and here is the manner of the weighing. A receiving bin is placed directly beneath the spout of the head of the marine leg. The bottom of the bin is a slide controlled by a lever. Beneath this bin is a scale with a hopper whose capacity is two hundred bushels. At the bottom of the hopper is a door so that when the grain is weighed it can drop through into another bin. In order to secure a proper economy of time and effort the weigher must adjust his scale beam to a standard weight and take just that amount into the hopper at each draught from the receiving bin. At first the slide is pulled wide open and the weigher stands upon the scale

platform beside the hopper. Then as the scale beam rises he bears less and less of his weight on the platform and at the same time gradually closes the slide, reducing the amount of grain that is being admitted from the receiving bin. The instant that all his weight is withdrawn and the scale balances, the slide is shut tight and the door at the bottom of the hopper is unlatched. It swings away, dumping the grain into the bin below and then by its counter-weight swings back again and is latched. That is not difficult if you are allowed to do it leisurely. But if you are to weigh all that the great marine leg is pumping out of the hold—fifteen thousand bushels an hour—you must repeat that performance every fifty seconds, which is a difficult matter.

This is nearly all of our story. The elevator at Port Arhur was a warehouse ; this at Depot Harbour is primarily a transfer house. The grain may be stored here but it is more likely that it will be carried across the house and out again as fast as the cars can be found to accommodate it. From here the wheat is taken in cars to the elevator at Coteau Landing, forty miles above Montreal. Whence loaded in barges, it is taken through the river and the system of canals to Montreal, where it is transferred to ocean steamships.

To understand the mode of operation in a seaport elevator remember our Port Arthur warehouse. There is but one important variation; that is in the method of putting the grain into the ships. At Port Arthur the barge lay right against the side of the elevator and the grain went into it through spouts, but your ocean freighter cannot do that. She lies at a pier and the grain is carried out to her on a belt conveyor.

The belt conveyor is simply our old friend the elevator leg stripped of its metal cups and lying on its side, that is, so that the belt travels parallel to the ground. The other devices that have been described were expedient, but they were noisy, dusty, strenuous ; this one is beautiful. Without noise, without apparent effort, the grain tumbles upon the swiftly moving belt and rides out, a ribbon three feet wide on the broader band of glistening white rubber, stretching out six hundred feet to the ship. You have seen a man make a running dive from a springboard ; that is the way our grain ends its journey to the sea. The belt that carries it rises slowly in a gradual incline to an iron frame containing a combination of broad, small diameter pulleys ; over them the belt makes a sharp bend and starts back to the elevator. But the ribbon goes

on, leaping free like the jet of a fountain, and without spilling a single golden kernel, without ceasing to be a ribbon, it pours silently down the black spout into the ship.

CANADA ATLANTIC RAILWAY ELEVATOR, DEPOT HARBOUR, CAN.

This elevator is located at the western terminus of the Canada Atlantic Railway, on the east shore of the Georgian Bay. It takes grain from boats which have been loaded at any of the great lake ports, and loads it into cars. For physical reasons the marine tower was built separate from the main house with which it is connected by a belt conveyor.

Total capacity of elevator in bushels	1,000,000
Length, in feet	290
Width, in feet	80
Total height, in feet	158
Number of bins	98
Depth, of bins, in feet	53 to 71
Capacity of bins, in bushels	1,400 to [illegible],000
Number of elevator legs	4
Capacity per hour each, in bushels	10,000 to 15.000
Capacity of scales, in pounds	72.000
Capacity of scale hoppers, in bushels	1,200
Number of distributing trolley spouts	2
Capacity from boats in ten hours, in bushels	150,000
Into cars in ten hours, in bushels	90,000
Length of power house, in feet	79
Width of power house, in feet	56
Number of boilers (horizontal tubular)	6
Style of engine and number: Two Horizontal Corliss Condensing.	
Kind of condenser,	jet.
Size and style of electric engine	10" x 18" Horizontal.
Size of dynamo	35 K.W.

THE MONTREAL WAREHOUSING COMPANY'S ELEVATOR.

The Montreal Warehousing Co.'s new fireproof elevator on Windmill Point, Montreal, Que., will be a steel structure with a capacity of one million bushels. The building will be 238 feet long

NOTE:—the elevators of the C. P. Railway system are enumerated on page 24.

and 84 feet wide. It will be built entirely of noncombustible material, the structure, bins, bin bottoms, etc., being of steel, roofs of tile and floors of concrete. The windows will have metal frames and be glazed with wire glass. A brick wall will surround the working story of the elevator and the cupola will be covered with galvanized corrugated steel.

The equipment will include 10 elevator legs, using 20" x 7" x 7" cups. Five of these legs will be used for receiving grain and all of them may be used for shipping. This gives a total elevating capacity of 100,000 bushels per hour. There will be five pairs of power shovels for unloading the cars, a car puller with four drums to pull cars in either direction on either of two tracks and two steel cleaning machines, each with a capacity of 4,000 bushels per hour.

The house will also be equipped with a passenger elevator and a sweeper system.

Grain will be weighed in ten hopper scales, each holding 2,000 bushels. Two 36" belt conveyors in the cupola will distribute the grain through the house longitudinally through trolley spouts on the distributing floors.

On the side of the elevator next to the Lachine canal a noncombustible marine tower will be built which will contain a marine leg capable of elevating 15,000 bushels of grain per hour. An extensive belt conveyor system will also be erected to deliver grain from the elevator to vessels lying in the Windmill Point Basin through a total of 19 marine loading spouts. These belt conveyors will all be 36" concentrated belts having a shipping capacity of 15,000 bushels per hour each. That is, the elevator can deliver to ships through its conveyors 30,000 bushels per hour. Two loading spouts will also be provided to load barges in Lachine canal basin No. 1. All machinery will be driven by electric motors. The foundations, which are now in place, are of concrete, resting upon piles.

FISHERIES.

The fisheries of Canada are :

(1) The Atlantic division, from the Bay of Fundy to the Coast of Labrador, embracing deep sea and inshore fisheries.

(2) The Estuarine and inland waters of the Eastern Maritime Provinces.

(3) The Great Laurentian lakes and rivers.

(4) The Great North West lakes.

(5) The Rocky Mountains rivers.

(6) The Pacific Coast.

(7) The Peri-Arctic fisheries at the mouth of the Mackenzie River and in Hudson Bay.

The value of the fisheries in the various provinces was, in 1902, as follows:—

Ontario	$1,265,706
Quebec	2,059,175
Nova Scotia	7,351,753
New Brunswick	3,912,514
Manitoba and Territories	1,119,437
British Columbia	5,284,824
Prince Edward Island	887,024
Total of Canada	$21,959,433

The Federal Government distributes $160,000 annually among the fisheries and vessels.

The number of vessels, tonnage and number of men receiving bounty in 1902 were:—

Number of vessels	795
Tonnage	25,521
Number of men	6,284

FORESTRY.

In 1903 the total value of the exports of wood, timber, lumber, etc., manufactured and unmanufactured (produce of Canada) was $40,859,967.

One of the growing industries in Canada is the manufacture of pulpwood.

The pulp wood region extends through all the Eastern provinces, goes as far north as Ungava Bay on the east side of Hudson Bay and as far north and north west on the west side of Hudson Bay as Coronation Gulf and the mouth of the Mackenzie River, thus constituting one of the greatest pulpwood regions in the world.

In 1903 there were 39 mills with an output of 275,619 tons of wood pulp of which 187,871 tons were mechanical pulp, 84,808 tons sulphite and 2,940 soda. The total value of the output was $5,219-892. There were nine sulphite pulp mills, three soda mills and 27 mechanical mills. Five made both chemical and mechanical pulp. The power required to drive these mills is chiefly water. Of the

total 110,630 horse-power required, 102,960 horse-power is water power. In 1881 there were only 5 establishments with a total output of $63,000. In 1891 there were 24 mills with an output of $1,057,810. In 1903 Canada supplied to Great Britain about 7.1% of her needs.

MINING.

Canada possesses ores of all the economic minerals, and the rarer minerals have also been found in the various provinces, but have not been mined to any extent, through lack of a market. Large quantities of the following metals and their ores are annually produced. The metals are named in the order in which their values appear, the first named having the largest value, and the last named the lowest: Gold, coal (and coke), copper, nickel, iron, silver and asbestos. For several years these metals and minerals have ranked in the order given above; the value of the total mineral production of the Dominion for 1903 was $63,226,510, of which the metallic production was about $34,000,000, and the non-metallic $29,000,000.

The important mineral products of each province are given in the following table in the order of their relative quantities and values:—

NOVA SCOTIA, INCLUDING CAPE BRETON.

Coal	5,000,000 tons
Pig Iron, Steel, etc	30,000 " $600,000
Coke	400,000 tons
Gold (free and in combination with sulphur, arsenic, etc.)	
Gypsum, Manganese, Antimony, Copper,	Are produced in a small way, although the shipments of gypsum sometimes amount to large quantities.

NEW BRUNSWICK.

Coal is being slowly developed, but it is of inferior quality and is comparatively remote from shipping facilities.

Ores of copper, iron and antimony occur in minor quantities.

QUEBEC.

Asbestos.—The most important mines of asbestos in North America are in the Eastern Townships of Quebec, and the value of their products exceeds $1,500,000.

Iron Ore.—Bog iron ore, mined in the Three Rivers District, etc., of Quebec, has supplied an important charcoal iron industry for a very long time. The production is small, but the value is considerable, owing to its great purity and the consequent high price commanded by the pig.

Mica.—The mica industry is important, and the value of the production exceeds that of any other district in North America.

Chromite.—Considerable quantities of this ore are produced, and the price which it commands is higher than the chromite produced from mines in North Carolina and Maryland. Probably the value of this product exceeds that of any other chrome iron district on the continent.

Gold and Phosphate of Lime are mined in a very small way; the gold occurs in gravels of both recent formation and of Silurian age. There are great possibilities for the successful mining of this metal in Quebec, but at present they are hampered by unwise legislation, enacted before the value of the gold deposits was known.

ONTARIO.

Nickel occurs chiefly associated with copper and small quantities of cobalt. The most important source of nickel in the whole world is in the district surrounding and adjacent to the town of Sudbury.

Copper occurs in the form of yellow sulphides in the District of Algoma, as at the Bruce Mines, Rock Lake and elsewhere, but it is produced chiefly as the second constituent of the Sudbury nickel ores, its value from these sources annually amounting to about three-fourths of a million dollars.

Iron Ore.—The third ore of importance in Ontario is hematite; it was mined on a large scale at the Helen Mine, in the Michipocoten District, also at the Josephine and Frances mines. In a smaller way it is mined at many other places. The country north and east of Lake Superior shows the surface outcrop of great iron deposits, chiefly hematite, but in places magnetite, which bid fair on development to equal the Mesabi, Biwabick and Gogebic ranges of the Michigan and Minnesota regions south of the lake.

Magnetite is mined to a small extent in Eastern Ontario.

Gold is mined in Eastern Ontario in the district lying between Peterborough and Prescott to a small extent, where it is associated with arsenic. In Western Ontario, or the Lake of the Woods Dis-

trict, the gold occurs in a free state and associated only with common pyrites. The amount produced annually is small, somewhat less than $300,000. Arsenic is produced in the Eastern district, in amounts ranging from 10,000 to 20,000 tons annually.

SILVER has been found and mined in the district lying from 20 to 30 miles northwest from Port Arthur on Lake Superior; the production varies, but has been large and the discovery of new deposits is probable.

CORUNDUM is being mined in a fairly large way in Eastern Ontario.

PETROLEUM is a very important mineral product of Ontario, the value of its annual production being at least $1,000,000.

SALT, ZINC, MICA AND GRAPHITE are minor industries of the Province.

NORTH WEST TERRITORIES.

COAL.—(a) Lignite is found in the Prairie and Plains sections in many localities, and is mined on a large scale for local domestic use, and also for steam purposes.

(b) Bituminous coal is found in the Western part of the Territories on the Eastern slope of the Rocky Mountains, and is being rapidly developed. The coal is of good coking quality and is being coked by both by-product and bee-hive oven methods, it is used not only in Canada, but also in large quantities in the North Western States adjoining the coal field.

(c) Lying along the Western border of the Province of Alberta true anthracite has been found in one locality near Banff. It has been mined for many years for domestic and steam uses, and has exhausted, but the C. P. R. have discovered a new and large deposit near Banff which they are rapidly developing, and the quantity of anthracite in this new deposit is very much larger than occurred at Banff.

GOLD AND GIPSUM are also mined in minor quantities.

BRITISH COLUMBIA.

GOLD.—The first product of British Columbia in value is its gold, which is produced in very considerable quantities as an element or metal in combination with the ores of the base metals, copper and lead. Free gold in British Columbia is diminishing in its output, and comes chiefly from alluvial mines. Vein mining for free gold

in British Columbia has not been very profitable, nor has it produced any considerable quantities. Promise of better returns has been given this year through the development of a remarkable mispickel mine in the Similkameen District.

Coal is produced in British Columbia on both the eastern boundary, as at Crow's Nest Pass, and on the coast, as on Vancouver Island: the eastern field surrounding the Crow's Nest Pass contains a very large number of seams of varying widths and of all qualities running from cretaceous or semi-lignitic coal down through the bituminous into semi-anthracite; only the bituminous coals are being mined. The most extensive works are at Fernie, Morrissey and Michel on the Crow's Nest Pass Branch line of the C. P. R. These coals are coking, and the coke is used in the furnaces at Trail, Nelson, Greenwood and Grand Forks, and is also shipped in large quantities to the furnaces in Montana, at Butte, Helena and Great Falls. Other coals are being found in the interior of British Columbia, and are being developed to some extent. These minor deposits occur in the Nicola Valley and in the Similkameen Country.

The coals of Vancouver Island have been mined for years, and have long been of great importance. They supply the local demand along the western coast of the province, and also are exported in large quantities to the seaboard towns of the United States which lie on the Pacific Coast. By far the largest quantity goes to the Port of San Francisco.

Copper.—This metal is a most important constituent of the pyrrhotite deposits of both the Rossland and Boundary country. It is used as a collector of the gold and silver values, and is smelted to a matte carrying from 15% to 30% of copper. The principal mines are located in the Boundary District, with those of the Rossland camp pushing them close for first place. The smelters using these ores are located at Nelson, Trail, Greenwood and Grand Forks and other places. There are also furnaces along the coast and on Vancouver Island of minor capacity, but which do a good business.

Lead is mined chiefly in the Kootenay districts. It is smelted at Trail and Nelson only. At Trail the pig lead is refined by the Dutch process known as the "Betz," which is a combination of electrolytic methods. The lead produced by this refining process is extremely pure, averaging over 99.7% of pure lead, and commands a very satisfactory price.

Silver occurs only as an associated metal with the galena or

lead ores of the province. It has not been found separately, but in conjunction with lead it forms a very important factor of the precious metal production.

ZINC.—This element, formerly an objectionable constituent of most of the lead ores of the Kootenays, is now being successfully separated, and treated or shipped by itself, and it forms a valuable product, adding considerably to the total mineral wealth produced each year by this western province.

IRON ORE.—British Columbia contains large deposits of high grade hematite iron ore, notably the large deposit at Kitchener in the Goat River Valley, and minor deposits have been discovered along the coast and at other points in the interior, but through lack of a market none of these deposits have as yet been opened up to any extent. The iron ore mined has been sold to the furnaces as a basic flux for their silicious ores.

YUKON.

The mineral products of the Yukon Territory are GOLD, SILVER and COAL, but gold is the only metal which has received much, if any, attention as yet. It is produced from alluvial mines, formerly through thawing the frozen gravels, digging them and raising them to the surface to be washed in the spring, but now the methods are being improved, and successful attempts have been made to mine these gravels with dredges and steam shovels, and during the past season by hydraulic methods.

SILVER is of minor importance, but is annually produced in small quantities.

COAL is now being mined in quantities of from 10,000 to 20,000 tons a year from two different beds along tributaries of the Yukon River. The quality of this coal is lignitic, but reports have been received which indicate the existence of beds of true bitumnous coal.

METHODS OF MINING.

Coal occurs in Canada in so many places and in such large seams, that only those which are of the best quality and are situated in the most accessible regions have as yet been mined. Witn certain few exceptions in the Province of Nova Scotia no great depths have been attained.

Coal mining methods in general are simpler than those of England, only large seams of three feet or more in thickness are attacked. In most cases some form of pillar and stall, or pillar and room, method is adopted for working, but in many of the collieries of Cape Breton the long wall method has been used and is preferred on account of its ability to win a larger percentage of coal from the whole field. The use of this method is of course largely governed by the quality of the roof.

In Nova Scotia, especially in Cape Breton, coal cutting machinery, actuated both by air and electricity, is much used. Haulage by wire rope has preference.

Along the eastern slope of the Rocky Mountains the cretaceous coals are found too irregular in thickness to make machine cutting profitable; in the coal beds of the Crow's Nest Pass district machine work has been tried and found to be feasible. The irregularities of these later coal measures has necessitated the use of more or less modified or special methods of mining, but as a rule the pillar and room system is the one in general use. The electric haulage is used at the mines of the Crow's Nest Pass Coal Company, and is found satisfactory, in spite of considerable quantities of gas being present. Haulage by wire rope is also in use.

METAL MINES.—Metal mines are operated and worked by the same methods that are employed elsewhere in the world. The narrower deposits, not in excess of 8′ to 10′ in width, practice the old standard methods of overhand stoping, and timbering with stulls and lagging; for large deposits the use of the open cut method (with or without the steam shovel) is employed at a few mines where it is practicable; a combination of open cut—or "Glory Hole" —with radial tunnels leading to underground loading bins from which the material mined is hoisted to the surface through a vertical shaft (known as the "milling system"), is employed in some of the very large, low grade copper deposits of the Boundary district in British Columbia. Caving systems are also occasionally employed. At Rossland, B. C., and generally throughout the country the square set system of timbering is in use on account of its great applicability to the varying widths of many of the western deposits.

UTILIZATION OF PRODUCTS.

COKE is made on Cape Breton Island and on the mainland of Nova Scotia, in the Crow's Nest District of British Columbia, at Fernie, Michel and Morrissey, and also on the Island of Vancouver.

In Cape Breton, Belgian ovens are used largely, and the more valuable by-products are saved, a portion of which are sent to the steel works at Sydney and are used to enrich the producer-gas. In the West, by-product ovens are used to a very small extent, since there is as yet little or no demand for the by-products, tar and ammonia, made by these ovens. Bee-hive ovens are in general use and give entire satisfaction, the coke made from them giving great satisfaction as a metallurgical fuel.

The coke made in Nova Scotia and Cape Breton is marketed entirely within the province, that made at the Crow's Nest Pass mines is marketed to the smelters in British Columbia and to the large metallurgical establishments of Butte, Great Falls and Helena, Montana.

COAL.—The coal of Cape Breton and the minerals of Nova Scotia supply first, the local markets of Nova Scotia; secondly, a very considerable market (amounting to nearly 1,000,000 tons) in the New England States; thirdly, the very large market of the St. Lawrence Valley comprising the cities of Quebec, Montreal and up-river ports; fourthly, the balance of the output, which is increasing rapidly each year, is consumed locally by the iron industry of the locality.

The total production of coal in Nova Scotia in 1903, was approximately five millions of tons.

The coal of the North West Territories is lignite and semi-bituminous in character. Its market is chiefly the prairie sections of the country, where the coal is used for domestic purposes; it is also used, to a less extent, on the railways of the interior and for steam purposes.

The coal of the Fernie coal field is of as good, if not better, quality than is found on the continent. It is bituminous in character and supplies the interior of the province of British Columbia for both domestic and steam purposes, and is very largely exported to Montana as steam coal to the mines, and for the supply of the Great Northern Railway Company.

The coal of Vancouver Island finds its greatest market in San Francisco and other cities of the Pacific coast; it also supplies all

the domestic requirements of the coast towns and some of the interior towns of British Columbia.

METALS:—IRON ORE is smelted on a large scale and in modern plants at Sydney, N. S., at Hamilton, Midland and Sault Ste. Marie in Ontario, and in smaller quantities at Londonderry,, N. S., Deseronto and Collingwood, Ont.

STEEL is made by open hearth methods at Sydney and New Glasgow, N. S., at Montreal, P. Q., and at the Sault Ste. Marie works in Ontario. Steel is made by the Bessemer Process by only one plant in Ontario, which is now idle.

COPPER is smelted to matte at Nelson, Trail, Greenwood and Grand Forks, B. C., also at one or two furnaces on the coast of British Columbia, as at Crofton, Ladysmith, Van Anda and other places. This matte is bessemerised at Greenwood and Grand Forks, it is also converted into black (or blister) copper at Nelson and Trail. This product goes finally to the United States for treatment.

NICKEL and the associated copper ores in the Sudbury District are matte-smelted and bessemerised at the mines. The final refining and separation was formerly done in New Jersey, U. S. A., but a refining plant is building at Sudbury and is expected to be finished during this year.

LEAD ORES are smelted at Trail and Nelson only, in British Columbia; this pig lead is desilverized and refined at Trail, B. C., by the Betz process before mentioned. Works for the manufacture of lead pipe are successfully running at Trail, B. C., and a plant for the manufacture of sheet lead is under construction at the same place. The furnaces and plant at Trail are the property of the Canadian Smelting Works, a branch corporation of the C. P. R., and this large corporation is now seriously considering the establishment of a plant at or near Montreal for the production of white lead from the refined pig lead of its works in Trail, B. C.

The following table shows a statement of the mineral production of Canada, published by the Geological Survey of Canada in February of this year.

TABLE XV.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1903

PRODUCT.		Quantity. (a)	Value. (a)
METALLIC.			$
Copper (b)	Lbs.	43,231,158	5.728,261
Gold, Yukon	$12,250,000		
" all other	6,584,490		
			18,834.490
Iron ore (exports)	Tons.	368,233	922,571
Pig iron from Canadian ore	"	42.052	707,838
Lead (c)	Lbs.	18,000,000	762,660
Nickel (d)	"	12,505,510	5.002,204
Silver (e)	Oz.	3,182,000	1,700,779
Zinc (i)	Lbs.	900,000	48,600
Total metallic		....	33,707,403
NON-METALLIC.			
Actinolite	Tons.	550	3,108
Arsenic	"	257	15,420
Asbestus	"	31,780	891,033
Asbestic	"	10,548	13,819
Chromite	"	3,383	33,830
Coal	"	7,996.634	15,957,946
Coke (f)	"	544,132	1,663,725
Corundum	"	no returns.	
Felspar	"	13,228	18,066
Fire clay	"	2,317	2,505
Graphite	"	738	23,745
Grindstones	"	5,538	48,302
Gypsum	"	307,489	384,259
Limestone for flux	"	277,45[illegible]	259,244
Manganese ore (exports)	"	135	1,889
Mica		....	159,473
Mineral pigments—			
Baryta	Tons.	1,163	3,931
Ochres	"	6,226	32,440
Mineral water		....	100,000
Moulding sand	Tons.	3,568	7,256
Natural gas (g)		....	168,900
Peat	Tons.	1.100	3,300
Petroleum (h)	Brls.	461,336	922,672
Phosphate	Tons.	1,329	8,214
Pyrites	"	33,530	126,133
Salt	"	53,537	334,088
Talc	"	688	2,064
Tripolite	"	835	16,700

TABLE VXI.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1903—*Concluded.*

Product.	Quantity. (a)	Value. (a)
Structural Materials and Clay Products.		$
Cement, natural rock........Brls.	92,252	75,655
" Portland........ "	627,741	1,090,842
Granite........		150,000
Pottery........	....	200,000
Sands and gravels (exports)........Tons	355,792	124,006
Sewer pipe........		317,970
Slate........	....	22,040
Terra-cotta, pressed brick, &c........	....	386,532
Building material, including bricks, building stone, lime, tiles, &c........	....	5,650,000
Total structural materials and cl products........	....	8,017,045
" all other non-metallic........	....	21,202,062
Total non-metallic........	....	29,219,107
" metallic........	....	33,707,403
Estimated value of mineral products not returned	....	300,000
Total, 1903........	....	63,226,510
1902, Total........	....	63,885,999
1901 "	....	66,339,158
1900 "	....	64,618,268
1899 "	....	49,584,027
1898 "	....	38,697,021
1897 "	....	28,661,430
1896 "	....	22,584,513
1895 "	....	20,648,964
1894 "	....	19,931,158
1893 "	....	20,035,082
1892 "	....	16,628,417
1891 "	....	18,976,616
1890 "	....	16,763,353
1889 "	....	14,013,913
1888 "	....	12,518,894
1887 "	....	11,321,331
1886 "	....	10,221,255

* The total production of pig iron in Canada in 1903, from Canadian and imported ores amounted to 297,885 tons, valued at $3,742,710, of which it is estimated 42,052 tons valued at $707,838, should be attributed to Canadian ore and 255,833 tons, valued at $3,034,872, to the ore imported.

(*a.*) Quantity or value of product marketed. The ton used is that of 2,000 lbs.

(*b.*) Copper contents of ore, matte, &c., at 13·235 cents per lb.

(*c.*) Lead contents of ores, &c., at 4·237 cents per lb.

(*d.*) Nickel contents of ore, matte, &c., at 40 cents per lb.

(*e.*) Silver contents of ore at 53.45 cents per oz.

(*f.*) Oven coke, all the production of Nova Scotia and British Columbia.

(*g.*) Gross return from sale of gas.

(*h.*) Includes crude oil sold to refiners and oil sold for fuel and other purposes.

(*i*) The contents of ores at 5.400 cents per lb.

INDUSTRIAL CANADA.

Among the large manufacturing establishments throughout the country, the following are especially interesting from an engineering standpoint.

The Canadian Pacific Railway shops at Montreal; the Locomotive & Machine Co., of Montreal; the Allis-Chalmers-Bullock, Ltd., at Rockfield, near Montreal; the Canadian General Electric Co., at Peterboro', Ont.; the Canadian Westinghouse Co., at Hamilton, Ont.

The Canadian Westinghouse Company has a new plant under construction at Hamilton for the manufacture of their electrical apparatus. The Westinghouse Manufacturing Company is already engaged in the manufacture of air brakes. The new shops consist of foundry, pattern shop, pattern storage, general machine shop, detail machine shop, warehouse, insulation treating building, boiler house, and transformer building. The lines of manufacturing to be taken up comprise, alternating and direct current generators, alternating and direct current motors, including railway motors, controllers, transformers, switchboard and switches, rheostats, instruments, meters, arc lamps, and various subsidiary apparatus.

The equipment of the plant will be on the most modern and improved lines as developed by the experience of the Pittsburg factories.

CANADIAN GENERAL ELECTRIC COMPANY, LTD.

The plant of the Canadian General Electric Company at Peterboro occupies about 40 acres. The largest building is the machine shop, covering an area of 81,232 square feet, and equipped with the most modern machinery. The motive power is obtained from the Company's plant at Nassau about six miles distant. The water wheels of 15,000 H.P. capacity, are of the horizontal turbine type, and each wheel is directly connected to two 450 K. W., three phase, revolving field generators operating at 138 R. P. M., and generating current at 60 cycles, 6,600 volts.

The Company controls the Canada Foundry Co., Ltd., at Davenport, Ont. The buildings connected with this industry cover at present 258,140 square feet (about six acres) of operative floor space. The shops are fitted throughout with the most modern machinery required for the construction of steam and electrical locomotives, boilers, engines, railway and highway bridges, electric travelling cranes, railway trucks, pumping machinery, water works supplies, etc.

THE ALLIS-CHALMERS-BULLOCK, LTD.

The Allis-Chalmers-Bullock, Ltd., is one of the companies most recently organized to supply the increasing demand for power machinery of all kinds. Their works are situated at Rockfield, P. Q. The shop buildings are modern, and there is every facility for the handling of the work.

The main machine shop is a building 400 ft. long and 100 ft. wide. The Allis-Chalmers-Bullock Company manufacture air compressors and pneumatic machinery, mining and mill machinery, steam and gas engines, water wheels, and electrical apparatus.

THE SHOPS OF THE CANADIAN PACIFIC RAILWAY COMPANY.

The Canadian Pacific Railway Company has under construction two large shops for the construction and repair of its railway stock, viz., the Angus shops at Montreal and the new shops at Winnipeg, Manitoba. It is expected that the first of these plants will be in complete operation by the end of the present year.

The site of the Montreal shop has an area of over 200 acres, and there are more than 20 buildings in all, covering a total area of 832,000 square feet or about 20 acres. Of these buildings, the largest, 162 ft. by 1,166 ft., will be used as a machine and erecting shop for locomotives. It is intended to repair here from 400 to 500 locomotives per year, and in addition to construct from 75 to 100 new ones. The shops are constructed in a plain, but substantial manner. All walls are of brick, and fire walls and curtains are put in wherever they do not interfere with the uses to which the buildings are to be put.

Heating System.—The hot air system has been adopted for heating purposes. Steam is distributed in tunnels to the different buildings from the central power house, which is about 2,600 feet from the most distant part of the system. The buildings have a combined volume of about 26,000,000 cubic feet, and from ¼ to ⅓ of the wall surface is glazed, besides which there are sky-lights aggregating 25% of the roof surface. The specifications require that most of the buildings should be heated to a constant temperature of 65° Fah. when the temperature outside is 10° below zero. The radiators for this surface contains an aggregate of about 200,000 linear feet of 1" pipe, in vertical coils, with cast iron bases, which are coupled up in sections of about 200 ft. each.

The fans are calculated to have a capacity sufficient to completely change the air in any building in about 20 minutes.

Method of Driving Machines.—All the machine tools, the cranes, the car transfer table to the passenger car shops, the fan motors for the exhaust fan and pressure fan in the blacksmith shop, the blowers in the foundry, and in fact all apparatus, except the fans of the heater system, and a small amount of hydraulic apparatus in the boiler shop are electrically driven. The power is distributed from the central power house to all parts of the grounds by 600 volt, three phase A. C. current, 7,200 alternations; but certain important machine tools in the locomotive shops and the frog shop, as well as all the travelling cranes and some small motors in the foundry, are operated by 250 volt continuous current.

Power Plant.—In the boiler room are 4-416 H.P. Babcock & Wilcox boilers built for a working pressure of 150 lbs. per square inch and superheat of 150° Fah., and 1-300 H.P. boiler (same make) built for a pressure of 300 lbs. per square inch, to be used in testing locomotives.

The induced draft system is employed in connection with a steel stack, eight ft. in diameter and 70 ft. high. The boiler house is also fitted with economizers, feed water heaters, ash hoists, etc. In the engine room there are three 750 H. P., and one 375 H. P. cross-compound, horizontal, Corliss engines, making 150 R. P. M., directly connected to three 500 K. W. and one 250 K. W., three phase, 600 volt, A. C. generators. Besides these generators there are two 250 K. W., 250 volt, D. C. dynamos for the crane service.

The equipment of the power house also includes air compressors, a 10 ton travelling crane, exciters, etc. A tunnel from the power house running to the most important buildings, carries on wall brackets the live steam pipe for heating by day, a high pressure steam pipe for locomotive tests, air pipe for pneumatic service, and return drain pipes.

Electric Installation.—In a total of about 200 electrical motors, about 15 are of variable speed. The system adopted as pointed out above, uses three phase, 600 volt current without transformers. All motors except the direct current are from 10 to 50 H.P. induction type. A suitable switchboard is installed in the power house for the distribution of the current. For shop and yard illumination there are 400-110 volt, enclosed arc lamps supplemented by 3,800-16 C.P. incandescent, 110 volt lamps.

Telephone Equipment.—The shops are equipped with a complete local telephone system, with a 75 drop switchboard and 60 telephones, besides others for long distance connection.

Arrangement of Machines.—In the shops, the small machine tools are arranged in groups. As a result of a series of practical tests, about 45% of the aggregate maximum H.P. was used as a basis for proportioning the sizes of the conductor mains to the motors.

The equipment of the Winnipeg shop is very similar to that of the Montreal shops.

THE LOCOMOTIVE & MACHINE COMPANY OF MONTREAL, LIMITED.

The shops of the above Company are situated at Longue Pointe about five miles from the centre of the City of Montreal. They cover a floor space of nearly 250,000 square feet, and are used for building locomotives and for structural steel work. The shops have a capacity of 250 locomotives per annum, and an annual output of struc-

tural steel of 12,000 tons. At present the number of employees is 1,000. The buildings are substantial and contain the most modern tool and labour saving devices.

In the power house are two generators, one engine driven, and one motor driven. The former machine is a three wire, direct current generator, with balancer giving two voltages for the variable speed motors. The lighting, both arc and incandescent, is done at 115 volts. The constant speed motors are operated at 230 volts, while the variable speed are connected by means of their controllers to the 115 or 230 volt circuits as required. These latter permit of a speed variation of four to one, and tools that require a greater speed range than this are equipped with gears or cone pulleys.

The motor equipment comprises some 140 motors, varying from three H.P. to 60 H.P., some shunt, some series and some compound wound.

Those interested in the construction of locomotives, structural steel work, or in electrically driven machine tools, will be well repaid by a visit to these works.

THE CARBIDE INDUSTRY.

A comparatively new industry in Canada is the production of carbide, which is being quite extensively used for the production of acetylene gas for lighting purposes. The Canadian Pacific Railway has, for example, lately adopted acetylene as their standard method of car illumination. The following serves as an illustration of how the carbide is produced.

The Ottawa Carbide Co., promoted and controlled by members of the Bronson Co., of Ottawa, has been manufacturing calcium carbide in the City of Ottawa, since the autumn of 1900. The carbide factory has at present a capacity of 4,000 tons per year, with additional room for adding 50% of this capacity, and provision being made so that the building can be extended to still further increase the output when necessary.

The power is furnished by the Ottawa Power Co., who have two 1,500 K. W., single phase, 7,200 alternations A. C. Generators direct connected to horizontal water turbines working under a head of from 25 to 35 ft. There are in addition, two small direct current units, which furnish exciting current and also sufficient power for driving the grinding machinery in the carbide plant. The power

is generated at 2,300 volts, and is transmitted a distance of about a quarter of a mile on two parallel copper lines, to the transformer room at the carbide factory. The power is there transformed to 75 volts (after passing through controlling switchboards), and is supplied to the furnaces at this voltage.

The carbide building is divided into seven sections representing the different operations in the manufacture. These are the grinding plant, furnace room, transformer room, regulating room, cooling and handling room, breaking room and packing room.

The transformer room is a long rectangular room immediately behind the furnace room, and contains the controlling switchboards and the transformers (one transformer for each furnace). The furnaces are arranged in a long line close to the wall separating the two rooms, and the transformers are in line immediately behind their respective furnaces.

The furnaces are of the Willson type, each consisting of a boiler plate tank, rectangular in section, larger at top (about three ft. square) than at bottom, each tank being mounted on a low four-wheeled truck. When in place these furnaces are in pairs in a long line, each being separated from its mate and from the next pair of furnaces by a permanent brick wall, and brick-work covering on top. This top is arranged with a hood to draw off gases and dust to a settling flue and steel chimney, and also carries the steel tanks in which is contained the mixed raw material.

Calcium carbide, a compound of calcium and carbon represented by the symbol CaC_2 is in practice made by smelting mixed coke and lime in the electric arc. The raw material has to be carefully selected to be free from sulphur and phosphorus, and has to go through a careful process of grinding and mixing before it is ready for the furnace. The grinding plant, situated at one corner of the factory, consists of five floors of steel plate and frame-work construction, the coke and lime being ground at opposite ends of this plant and mixed in the centre. Both materials require several grindings and screenings before being suitable for mixing, and the consequent handling from one machine to another automatically, makes the great height necessary. From the mixing tanks the mixed material is carried by means of a plate conveyor to fill the tanks on top of the furnaces.

The bottom of each furnace is formed of a solid, hard, baked mass of carbon, and can be connected electrically to one terminal of

the transformer. The other terminal of the transformer is connected to a long, vertically hanging rod, to the bottom of which is attached a carbon electrode some 18″ long and of rectangular cross section. This rod and electrode can be moved vertically by means of a chain and hoist in the regulating room (situated directly above the transformer room). The control is by hand, the operators having in front of them a volt meter and ammeter for each furnace, their duty being to maintain an approximately constant current on each, the voltage being controlled from the power house. The operation is started by striking an arc between the electrode and the furnace bottom, raw material being then supplied to the furnace by the attendants, who control openings in the bottoms of the raw material tanks. As the material comes under the action of the arc, it is fused and carbide is formed, the arc shortens and resistance drops; the current then rises and is indicated on the ammeter in front of the attendant; he raises his electrode until the current again becomes normal; this operation is continued until a "pig" of carbide, weighing some 300 to 400 pounds, is formed, the electrode having risen a height of perhaps two feet. The steel plate of the tank is protected from the intense heat of the carbide by part of the mixed material which is unacted on, this varying in thickness from six inches to 16 inches. The power used in each furnace is about 150 K. W., viz., 2,000 amperes at 75 volts.

The average output of the process is in round numbers, one ton of carbide, per horse power, year. The present capacity of this plant using 4,000 H.P. (3,000 K. W.) is, therefore, 4,000 tons per year (continuous operation six days per week).

As the carbide is only molten at a very high temperature, skin forms on the outside of the "pig." When the operation is completed the truck and furnace containing the "pig" is disconnected and wheeled out from its brick arch to the cooling room, where it is handled by a travelling crane and allowed to stand to cool for a few hours. The "pig" is then hard enough to dump, and after dumping, is allowed to cool still further before handling. The outer crust and hard skin, consisting of a low grade quality of carbide, is then peeled off with pneumatic chisels, the "pig" broken into large pieces with sledges and put into a crusher. From the crusher it passes through a screen, which sifts and sorts the carbide into various sizes for commercial use. These different sizes are then packed in air tight, steel cans, the usual size containing 100 lbs. of carbide.

MANUFACTURES, GENERAL.

By comparing the returns of the 1901 census with those of 1891, the following conclusions may be drawn concerning the development of those manufactures having five or more employees.

(1) Consolidation, shown in the decrease of the number of establishments. (2) Great increase in the capital invested. (3) Increase in the value of the product per employee.

The following table gives a summary of the manufacturers of 1901 having five or more employees.

TABLE XVI.

	No. of Establishments.	Capital.	Employees.	Value of Products.
Arms and ammunition...	14	$ 1,675,675	611	$ 1,054,000
Books and stationery....	519	17,235,971	10,724	13,796,151
Carriages, etc..	409	14,941,702	14,453	19,420,999
Chemicals	120	5,710,843	2,259	6,368,743
Drinks and stimulants...	384	39,340,286	11,275	36,034,328
Fibrous material	79	3,901,905	2,621	4,211,806
Food, animal	1,218	13,896,363	18,030	31,951,369
Foods, vegetable	793	24,781,251	15,705	47,492,461
Furniture, houses and buildings	888	22,409,724	17,163	24,983,932
Gold, silver, jewellery, &c.	54	2,260,430	1,544	2,491,622
Leather, boots and shoes, &c.	439	21,558,890	19,332	34,853,019
Lighting, supplies, etc...	132	27,632,868	4,810	11,317,374
Machines, tools and implements	969	77,712,502	38,923	61,636,978
Matters, animal..	63	3,085,130	1,364	3,325,159
Matters, vegetable	2,969	84,319,298	66,475	71,713,699
Mathematical instruments, etc.	4	115,700	140	199,750
Musical instruments	46	4,290,847	2,669	3,380,727
Ships and boats..........	60	3,503,434	2,744	2,291,668
Stone, clay and glass.....	677	7,117,245	9,370	5,820,544
Textile fabrics and dress.	1,648	55,732,164	62,705	62,035,654
Miscellaneous	141	9,770,828	3,777	8,390,994
Total	11,126	$441,053,060	306,694	$452,775,577

TABLE XVII.

SHIPPING.

The following is a comparative statement of sea going vessels arrived at and departed from Canadian ports (exclusive of coasting vessels) in 1902 and 1903, distinguishing between British, Canadian and foreign vessels.

Nationalities.	Number of Vessels.	Tons Register.	Freight.		Number of Men.
			Tons Weight.	Tons Measurement	
1902.					
British	4,363	6,865,924	3,338,040	1,067,694	184,102
Canadian	11,413	1,937,227	759,864	486,897	125,022
Foreign	14,530	5,928,337	2,126,340	904,631	277,027
Total	30,306	14,731,488	6.294,264	2,459,222	586,151
1903.					
British	4,647	7,753,788	4,246,640	1,091,751	240,695
Canadian	11,282	2,085.568	998,247	375,956	128,563
Foreign	2,403	6,001,819	2,394,626	837,127	271,421
Total	28,332	15,841,175	7,697,513	2,304,840	604,679

THE DOCKS AT QUEBEC AND MONTREAL are described as illustrating the shipping facilities of the Dominion.

THE HARBOUR of Montreal covers an area of about 4,000 acres, and is approximately eight miles in length by nearly one mile in width. The Lachine Canal (with 14 ft. depth of water) enters the harbour near its up stream end. The wharves now built, with the additions to be finished early in 1905, give the following berth frontages at extreme low water:—

For 20 ft. depth and under....	3,569	ft.	or	0,676	miles.
" 25 ft. to 27½ ft. depth......	19,098	"	"	3,615	"
" 32 ft. depth	15,239	"	"	2,887	"
" 35 ft. depth	900	"	"	0,170	"
Total..	38,806	ft.	or	7.349	miles.

These wharves are, with the exception of some of the old shallow water wharves, in general 200 ft. to 300 ft. in width, and are equipped with railway tracks entering from both ends of the harbour. The newer and deep water wharves are being paved with granite block pavement on a concrete foundation, and furnished with the most modern arrangement of track sidings and cross-over switches, amounting in most cases to six tracks on the larger wharves.

Steel freight sheds are now under construction. These sheds are 96 feet wide, having two floors and a total length of 6,759 feet, giving a floor area of 648,864 square feet (nearly 15 acres). The sheds will be equipped with the most modern facilities, will have the car floors alongside the lower floors at even height, and will give access for waggons to both lower and upper floors, as well as have roadways alongside which will put the lorry platform on a level with the shed floors. Some of the sheds will be ready for the opening of navigation in 1905, and all will be ready for 1906.

Large coal handling towers transfer coal from the ships to the wharf, or directly to railway cars, and more of these towers are in process of construction.

Up to the present time a fleet of grain elevators have transferred the grain from inland barges and boats to ocean vessels. One grain elevator (1,000,000 bushels capacity) has just been finished, and another of equal capacity will be finished in 1905. (See page 47.) These elevators will take grain directly either from inland vessels or from railway cars and deliver it to ocean ships.

AT QUEBEC are the Princess Louise docks constructed by the Quebec Harbour Commissioners, and administered by them.

The tidal harbour has an area of 20 acres, and the wet dock an area of 40 acres.

The quay frontage of the tidal harbour and river front piers is 4,600 lin. feet, and of the wet dock 3,500 feet.

The quay surface is some 50 acres in extent, on which there are five miles of railway tracks, connecting with the various railways terminating at Quebec.

Along the quay front are landing sheds with a floor area of 174,000 sqr. feet. One grain elevator of 1,000,000 bushels capacity, serving two loading berths. One grain elevator of 250,000 bushels capacity, serving one berth, and one cold store with 100,000 cub. ft. of refrigerated space.

At St. Joseph, Levis, is a graving dock of the following dimensions constructed by the Quebec Harbour Commissioners, administered by the Federal Government.

Length..	600	ft.
Width..	100	"
Entrance width..	62	"
Entrance sill below low water..	7½	"
Rise of spring-tides..	18	"
Inaugurated September 23rd, 1886..		
First vessel docked, September 1st, 1886.....		

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MEMORANDUM

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Schoolcraf
Scotia Jct.
Scotts, Mic
Seaforth, O
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Sedley, Ind
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Shannonvi
Shelburne,
Shepards
Sherbrook
Sheridan,
Sherringto
Sherks, On
Simcoe, On
Slocum, M
Smith's Cr
Southampt
South Bend
South Durh
South Lyon
South Pari
South Park
South Rive
Sparta, Mic
Springford,
Spring Lak
Stark, N. H
Stayner, On
Stevensvill
Stewarttow
Stillwell, In
Sterling, O
Stockbridge
Stoney Cre
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Stouffville,
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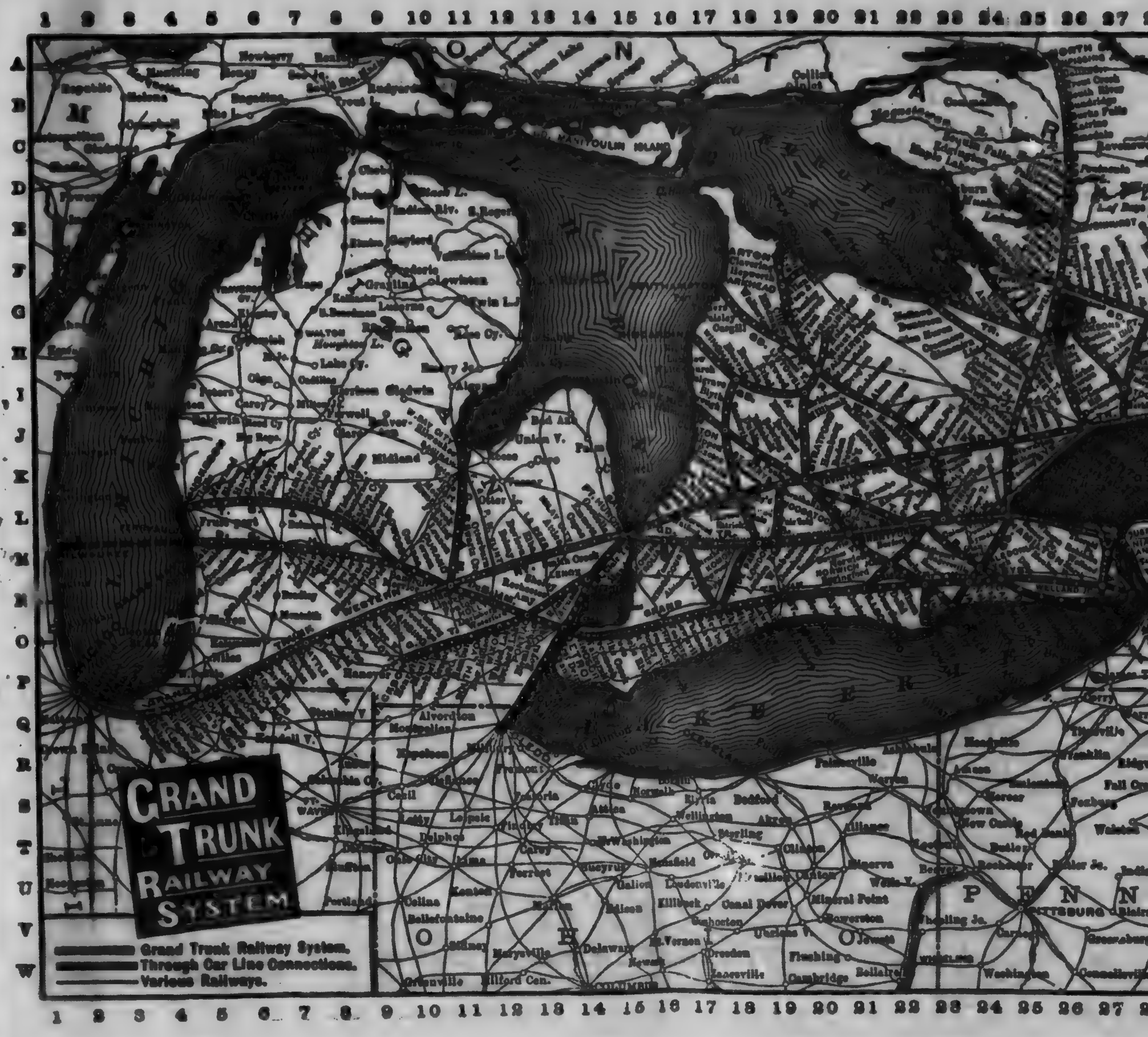
GRAND TRUNK RAILWAY SYSTEM
Grand Trunk Railway System.
Through Car Line Connections.
Various Railways.
MANITOULIN ISLAND
Midland
Alvordton
Montpelier
Napoleon
Paynesville
Painesville
Warren
Ashtabula
Alliance
Canton
Massillon
Minerva
Mineral Point
Mansfield
Loudonville
Galion
Marion
Delaware
Columbus
Zanesville
Cambridge
Bellaire
Washington
Pittsburg
Rochester
New Castle
Mercer
Franklin
Marysville
Greenville
Celina
Portland
Lima
Delphos
Kenton
Bellefontaine


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Q U E B E C
ONTARIO
Sharbot Lake
Philadelphia
Carthage
Adams
Richland
Lyons Jc.
Camden
Rochester
SUSPENSION BRIDGE
GENEVA
SYRACUSE
Cazenovia
Cherry Val.
Schenect.
ALBANY
Cortland
Norwich
Sidney
Walton
Hancock Jc.
Rondout
Highland
Carbondale
Wellsville
Olean
Bradford
Ridgway
Driftwood
Williamsport
Lock Haven
Clearfield
Sunbury
Bellefonte
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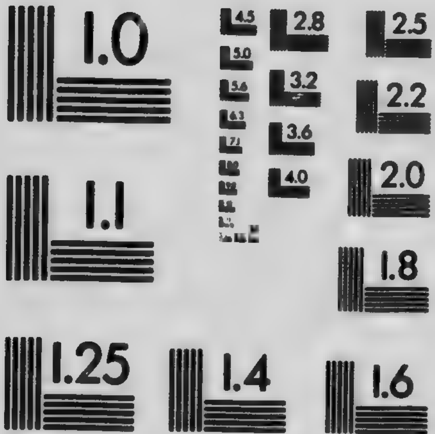

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